Pesticides in India

ENVIRONMENT AND HEALTH SOURCEBOOK

TOXICSLINK
NOVEMBER 2000

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Researched and compiled by: Dr Amit Nair

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Content

Preface

India produces over 93 pesticides, but the health and environmental effects of fewer than 50 per cent of them are known. Our pesticide industry, producing about 90,000 metric tonnes annually, is the largest in Asia and ranks twelfth in the world. Though pesticide usage is low per hectare, indiscriminate usage has made it a major source of water pollution and food contamination. A 1995 study found 55.1 per cent of farmgate vegetables contaminated, and almost 10 per cent had levels exceeding those acceptable.

Pesticides constitute one of the major non-point pollution sources of our ground and surface water. There are almost no mechanisms for cleaning our life-giving water supplies of such chemicals, and our water treatment plants do not even attempt to cleanse them. In fact, water is not tested for many such chemicals, besides the fact that only a handful of laboratories can test for only some of them, and that too at a very high cost.

There has also been continuous reporting of the effect of these chemicals on our wildlife. Foraging birds such as peacocks and cranes, especially our majestic Sarus Cranes, have either been killed or had their breeding patterns disturbed. Top-of-food-chain birds such as eagles accumulate magnified amounts of these chemicals and these have been known to cause thinning in eggshells. Ornithologists have noticed smaller species disappear from areas with high pesticide usage over time, and fish kills are not uncommon. In humans too many effects have been recorded. Delhi has a very high concentration of DDT in mother's milk and there are reports of increasing infertility – both male as well as female.

Unfortunately, all these require studies which are long-term and very expensive to do, for 'conclusive' proof. It is here that we must think of precaution before cure. Emerging patterns should be strong indicators of something going wrong. Theo Colburn in 'Our Stolen Future', and earlier Rachel Carson in her classic 'Silent Spring' have all traced such patterns to a range of chemicals which act not only in large doses but in very minute quantities.

Despite this, India has had an unclear pesticide policy, and linkages between pesticides and environment and human health either not researched or ignored. This sourcebook is an attempt to compile all such evidence available in the Indian context. It is also an institutional directory, as well as an attempt to simplify the subject. It is hoped that there will be a heightened awareness on the issue, since it concerns us all, especially through the food we eat and the water we drink.

Ravi Agarwal
Toxics Link

Introduction

In the last four decades, there has been an increasing global concern on the toxicological consequences of chemical pesticides. A major concern has been the prevalence of pesticide residues globally. Pesticides have entered the natural food chains, contaminating all strata of the ecosystem. Humans, being on the top of the food chain, are most vulnerable to health risks, as the intake of pesticides is several-fold higher through the process of biomagnification in the food chain — the consequence of which is being faced by not only the present, but also the future generations.

Over reliance on synthetic pesticides is the root cause of the problem of environmental contamination in India. Although the average pesticide use in India of 0.57 kg/hectare is low compared to the 2.5 to 3.0 kg/hectare in USA and Europe, Indians show the highest levels of DDT in their bodies. This is due to the non-judicious use and overuse of pesticides. This can be attributed to lack of information, training and awareness amongst the farmers about safe pesticide application, safe waiting periods, minimum use of chemicals, and also the use of spurious or adulterated pesticides. Being ill-informed, farmers apply pesticides even in places where there have been no pest outbreaks, just as a protective mechanism. Further, labelling and specifications on pesticide containers, if any, are usually incomprehensible to illiterate farmers; therefore, they tend to ignore them and harvest crops before their waiting periods are over. And, as a consequence, pesticide-laden vegetables, fruits and cereals are released in the market for the consumer.

Although there is a trend showing decline in the levels of pesticides in food commodities in India as compared to previous surveys, it still leaves much to be desired, as most food commodities contain pesticides. Many developed countries have re-evaluated the tolerance limits for pesticides and have set much lower limits, consequently minimizing the intake of pesticides through food. Unless India also re-evaluates and lowers its tolerance limits of pesticides in food commodities, nothing significant can be achieved.

Even the vector control programmes in the country suffered a severe setback as the vector populations began resisting and evolving biochemical mechanisms of detoxifying pesticides within their bodies. Continued ad hoc use of insecticides without a proper understanding of their intricate mechanisms has aggravated the problem of pest menace and resulted in the resurgence of many pests. More than 160 species of insect vectors have become resistant to major groups of insecticides. This is due to the lack of foresight on the part of the pesticide and agricultural scientists to anticipate the natural selective mechanisms of insects.

The data from the International Development Research Centre, Canada, shows that every year about 10,000 people die and another 400,000 suffer from various effects of pesticide poisoning in developing countries. India accounts for one third of pesticide poisoning cases in the third world. Farm workers are the worst affected.

Cases of blindness, cancer, premature delivery, abortions, deformities, diseases of the liver and nervous system from pesticide poisoning have been identified in Andhra Pradesh and Maharashtra. The alarming rise of pesticide poisoning is attributed to the increasing number of toxic chemicals and their large-scale use without proper testing of their toxic properties. A number of such chemicals banned in the western countries are dumped in the third world countries.

Legislatively, it is mandatory that the Central Insecticide Board, a body formed under the Insecticide Act 1968, furnish details of a pesticide prior to its registration, before it becomes available in the market. The precondition for registration is that every pesticide which is available in the market should have the tolerance limit and waiting period, i.e., the minimum interval between last application and harvest with respect to farm products. There are 147 pesticides registered in India. However, tolerance limits for only 50 pesticides are available. Hence, we are exposed to a wide spectrum of pesticides whose toxicological implications are not known.

A number of pesticides available are suspected to be carcinogenic or teratogenic. The developed countries have been emphasizing on more stringent laws prior to registration. They have been re-evaluating from time to time the tolerance limits of pesticides which were laid down for foodstuffs and are making them more stringent so as to minimize human exposure. Separate tolerance limits of pesticides for infants have been laid down which are four to five folds lower than those recommended for adults, as they are more vulnerable to these chemicals. India too should set such tolerance limits for infants.

It is evident that we rely too much on chemical pesticides even though other safer methods such as Integrated Pest Management (IPM) are available. Due to strong lobbying from the pesticide industry in the country, synthetic chemical pesticides remain as the only control mechanism for pests. Although IPM has been very successfully applied in many countries, in India nothing much has been done about it except on paper. Similarly, organic farming, a safe and sustainable method, has hardly received any attention. Farmers engaged in organic farming are not given the same subsidies as those engaged in pesticide-intensive farming, and markets for organic produce in the country are almost non-existent.

There is no national pesticide policy in the country. The only legislation governing the use and manufacture of pesticides is the Insecticide Act of 1968. The extremely rich and powerful lobby of the pesticide industry controls government policies. The decision takers and policy makers, who lack knowledge of pesticide science, have brought in policies without consulting the pesticide experts.

What needs to be done?

- The Insecticide Act of 1968 covers almost all aspects regarding pesticide usage. However, it should be reviewed, updated and made more relevant with the passage of time, as many more facts have emerged on pesticides after 1968.

- A National Pesticide Policy should be formulated, where the final say of the feasibility of the policies should be entrusted to the pesticide experts.
- A nodal centre should be set up and entrusted with planning and implementing research on environmental protection from pesticides, disseminating information on the utilization of developed technologies and evolving and monitoring safe pest control practices and policies.
- Pesticide registration should be made very stringent. No pesticide should be allowed to enter the market unless all the criteria for registration are fulfilled. The data required for registration of pesticides should also include results of carcinogenicity, teratogenic potential and neurotoxicity. The Central Insecticide Board should be made responsible for irregularities in pesticide registration. The enforcement agencies should be given more powers so as to prosecute erring industries/officials responsible for any irregularity.
- The pesticide industry, which is the main polluter, should be taxed or should pay for developing decontamination technologies. The industry should concentrate on the development of safer and less risky pesticides. Also, the pesticide industry should be made responsible for creating awareness among farmers about it's products, such as safe application in the field, judicious use, problems emerging due to misuse, and health hazards.
- Monitoring of pesticides in food commodities should be done regularly.
- Tolerance limits for pesticides should be re-evaluated and made lower in comparison with the existing ones. A new set of tolerance limits should be stipulated for infants.
- Studies on the health effects of pesticides as well as epidemiological studies should be conducted to further minimize the intake of pesticides.
- Integrated pest control measures, organic farming and use of biopesticides should be promoted and subsidies and markets for organic produce should be created.
- A national programme to create mass awareness on pesticides, to monitor pesticide residues and to assess their environmental impact, need to be launched and sustained.

Chemical Warfare

Bittu Sahgal

Insects help us in uncounted ways. If there were no ladybirds around, for instance, aphids would destroy vast quantities of our crops. Wasps too eat creatures which would otherwise consume our farm produce. Butterflies do not merely lend quality to our lives because of their gentle, attractive ways; they are essential for pollination; without butterflies, thousands of flowering plants upon which millions of humans depend, would vanish from the earth.

I find it rather silly that humans have chosen to declare war on insects through the use of poisons (insecticides). There is no doubt that caterpillars, beetles and grasshoppers pose a problem to farmers because they eat our food crops. But the Food and Agriculture Organisation (FAO) of the United Nations has more than enough proof on hand to indicate that our crops cannot be protected indefinitely by poisoning the 'enemy'. This has not stopped us from waging our absurd chemical war against insects. As of now, the toxic load on the ecosystems upon which we are collectively dependent has risen to the point where the course of evolution for a vast number of species is being seriously affected.

We kill billions of grasshoppers each year, but their populations continue to rise, as does the quantity of crops they consume. The strange thing is, pesticide manufacturers are happy about this failure on their part, because each time a farmer loses a crop to insects, he winds up buying still more deadly poisons.

Why will we inevitably lose the pesticide-grasshopper-caterpillar-thrip-weevil war? Because the processes of evolution are on the side of the little ones. Pesticides apply selective pressure on species in the same manner as do droughts, floods or climate change. Evolution has armed insects with the ability to alter their genes so as to: 1. Avoid our poisons. 2. Reduce their toxic impact. 3. Manufacture antidotes fast. If the above defences don't work, insects have yet another trick up their sleeves! They can actually move or shrink the vital organs in their bodies that our pesticides target. The engine driving these defences is evolution.

And it's not just insects that are being affected. In Kaziranga, Assam, pesticide residues from tea estates could cause severe endocrine disruption in the food web of the rhinos. In the Keoladeo Ghana National Park, major pesticide contamination is affecting the breeding biology of birds, particularly raptors. The pesticides, including the banned DDT and other organochlorines, enter through the water from the Ajan Bund. Toxic pesticides are being released in forest soils. And the food that we eat is also not exempt from being contaminated by pesticides. You could be living in the most posh locality, but the fish you eat is probably laced with heavy metals. And the apples and grapes you consume could be bathed in deadly poisons.

'As you sow, so shall you reap. If you sow pesticides, you will reap poison.' The words of an American organic farmer ring truer than ever in Punjab, where mothers now feed their children 40 times the safe levels of DDT in breast milk. Around the

world, more than three million people suffer from acute pesticide poisoning every year, of which 200,000 actually die — mostly in countries such as India.

The way out

'As crude a weapon as the cave man's club, the chemical barrage has been hurled against the fabric of life — a fabric on the one hand delicate and destructible, on the other miraculously tough and resilient and capable of striking back in unexpected ways.' *Rachel Carson*

We will never be able to eliminate insects (nor would we want to). So what can we do about the problem of insects eating up our food? A lot. For starters, we need to grow different kinds of food or fruit on our farms. When we grow only one or two kinds, we provide an endless banquet for specific 'pests', which consequently multiply uncontrolled. By growing different kinds of food-plants, we limit the scope for insects to proliferate, since one kind of insect normally eats only one kind of food. This keeps them in check. We can also choose to grow tough, robust species of food-plants, rather than the sickly, weak (but attractive to look at) fruits and vegetables that wind up on our tables.

Yet another option, perhaps the key option, is the use of natural predators to keep insect populations down. Lizards, frogs, spiders, praying mantises, birds and even bats eat insects. If we left places (called niches) on our farms suitable for such predators, it stands to reason that insect populations would fall. Spraying farms with insecticides, weedicides and herbicides eventually winds up killing insect predators instead, leaving the ground open for 'pests' to multiply even more freely.

We need to take some lessons from nature. In the rain forest, for instance, no artificial chemical fertilisers are necessary because ants, termites, fungi and mosses combine to convert fallen leaves, twigs and trees back into nutritious food for new plants. If we too chose to use natural fertilisers such as cow dung and if we composted organic wastes on our fields, we could avoid poisoning ourselves and the many organisms (such as earthworms), which look after the soil.

Balancing act

Nature thrives on balance. In the case of pest control, the best way to ensure balance is to understand predator-prey relationships. Nature invariably fills a vacuum and the sheer abundance of insects therefore led to the evolution of predators, which fed on them. These predators hold the key to the balance we seek in the battle to protect our food from the invading hordes. Perhaps people ignore such advice because they seldom get a close-up view of fascinating creatures such as dragonflies and grasshoppers, whose deaths we cause by our lifestyle options, including the use of pesticides, and the decimation of wetlands. In time, one can only hope that smart individuals from among the younger generation will emerge to take charge of the earth and run it in a more responsible manner than adults are doing right now.

Bittu Sahgal *is the Editor of Sanctuary Magazine*

Household Pesticides and the Indifferent Consumer

Bharath Jairaj

Consumers the world over encounter pesticides in various forms and meant for various purposes. We use pesticides in our attempts to deal with household and other pests commonly found. There are a range of pest control and management methods. These could include physical and mechanical methods, biological control, chemical control and IPM (Integrated Pest Management).

- Physical and mechanical methods of pest management are the oldest form of pest control used by consumers. This involves the use of devices and gadgets to trap and kill pests, and includes traps, insect screens and nets, baits and plant guards.
- Biological control methods involve the use of parasites, predators and pathogens for the reduction of pest populations.
- Natural alternatives include use of organic methods and homemade pesticides like bio-sprays with minimal human health impacts.
- Chemical control methods include both organic substances like pyrethrum and inorganic derivatives of sulphur, mercury, arsenic and other metals, and synthetic compounds that are bulk manufactured in factories and chemical laboratories. Over 90 per cent of the pesticides used today fall under this latter category of synthetic pesticides. Most pesticides work by absorption (contact poisons) or ingestion (stomach poisons). Longer-lasting pesticides are described as being residual.
- IPM is a holistic system that reduces damage caused by pests to tolerable levels through a mixture of all the above techniques. IPM does not recommend the use of chemical control, except as a final resort, and even then, only the least toxic chemical at the least required dosage can be used, with all the necessary safety precautions taken.

With India being home to several thousand species of pests, known to be the cause for the spread of many diseases, the typical reaction of government and consumers alike has been to reach for the most severe form of pesticide available — the synthetic pesticide — for dealing with every pest problem. Governments generously pour volumes of dangerous organochlorines, organophosphates and the like down municipal drains, or randomly release poisons in the form of sprays in unsuspecting communities. This needs to be resisted and stopped immediately.

Consumers, on the other hand, have the luxury of choosing from a variety of 'easy-to-use' pesticide products available on the shelves of supermarkets and local grocery stores. Found in attractive bottles, cans, boxes, tins and several other containers, and in the form of oils, aerosols, sprays, powders, chalk, coils, mats, solutions and other forms, these poisonous substances are stored, purchased, handled, used and disposed of with minimal care, if any.

Most pesticide products do contain warnings, information about the active ingredients, directions for safe use and other safety information, including medical warnings, poisoning symptoms and first aid instructions. Unfortunately, very few consumers pay attention to these. We fail to read the label or the instruction sheet provided inside the packet and so pay virtually no care while opening, using, storing or disposing of the pesticide or its container.

The hazards of improper and unsafe handling, storage and disposal of these pesticides are well-documented and need to be understood by consumers. While on one hand, consumers need to read labels carefully and follow safety instructions printed, we also need to become aware of the non-chemical, non-synthetic choices available in the market today. We need to give more attention to pest prevention and make use of the several forms of non-toxic pest management methods existing today.

Similarly, advertisements and promotions carried out by pesticide manufacturers need to be carefully scrutinised by consumer groups and consumers alike. This need becomes more acute when such advertisements are targeted towards vulnerable groups like farmers, and make misleading claims about safety, especially of children.

The problem with pesticide residues is affecting consumers even more, as such pesticides have been accumulating in humans due to improper handling, storage and disposal. These could accumulate even when instructions on the label are strictly followed, perhaps through indirect contact. Hence, pesticides used in agriculture have appeared in fruits, vegetables, meat and recently in wheat flour as well. A recent test by the Ahmedabad based Consumer Education and Research Centre (CERC) revealed that all 13 brands of wheat flour tested contained pesticide residues. Five brands tested positive for DDT and DDE.

Consumers as a group are capable of designing government policy. And on the issue of pesticides, consumers in India have remained silent for too long. It is time that we became aware of the hazards and dangers of synthetic pesticides and used our power of choice to stop endorsing synthetic pesticides. At the same time, consumers must join hands with environmental groups and anti toxics campaigners and lobby the government to ensure a complete phase-out of these dangerous substances from not just our homes and markets, but from the entire global scenario.

Bharath Jairaj *is a consumer lawyer and activist with Citizen, Consumer and Civic Action Group, Chennai.*

Health and Diagnostic Problems Associated with Pesticides

Prof. Dr. Devika Nag.

Pesticides can affect all systems of the body, but the maximum brunt is borne by the central nervous system. The widespread use of pesticides in farms, fields and homes and their insidious entry into the food chain — fruits, vegetables, cereals, milk and meat — is of concern to all doctors dealing with the problems of the nervous system like behavioural defects, cognitive changes and peripheral nerve disorders. The most common class of pesticides used are organochlorines, organophosphates, synthetic pyrethroids, carbamates, aluminum phosphide, arsenic based pesticides (Paris green) and nicotine. Aldrin, dieldrin, DDT, BHC (banned but still available), malathion, parathion, fenthion and endosulfan are some in use, to name a few.

Systematic data collection of pesticide use in India is almost non-existent. Nuggets of information are gleaned from major urban cities, but no accurate information is available from rural areas, where use of pesticide is high. Data on human toxic effects — neurotoxic and others, have been collected from Ahmedabad, Chennai, Delhi, Calcutta, Chandigarh, Pune, Rohtak, Mumbai and Lucknow.

Human toxicity due to chronic/acute pesticide exposure may be summarized as follows:

- Central nervous system: Epileptic fits, myoclonus, dyskinesias, headache, encephalopathy, macula degeneration, peripheral neuropathy, sensorimotor dysfunction, cognitive defect, behavioural disorders, decrease in acuity of smell and taste, cranial nerve palsies, Parkinson's syndrome, motorneuron diseases like sensory disorder, tremor syndromes and organophosphate induced delayed neuropathy (OPIDN) syndrome;
- Acute pulmonary oedema, respiratory disorders, asthma;
- Hormonal disbalance, decreased sperm count azoospermia, ciracadian rhythm changes, miscarriages, change in libido;
- Gastrointestinal: severe abdominal pain, cramps, diarrhoea, incontinence of faeces;
- Cardiovascular: bradycardia, hypotension, ventricular arrythmias, heart block;
- Skin dermatitis;
- Mutagenesis and teratogenesis;
- Carcinogenesis, especially of liver and reproductive organs.

Indicators like Acceptable Daily Intake and Maximum Residue Limit, which show the potential toxic effects of pesticide exposure, are based on toxicological data collected from global sources, which may not be so true for Indian conditions. The climate, humidity, genetic/racial differences and the nutritional status of Indians compared to Caucasians, have therefore not been taken into account. Indians have

the highest DDT levels in the adipose tissues compared to other countries.

Pesticides are the commonest used chemical for suicide, even today, due to easy availability. Doctors are not trained in the current curricula for differentiating between the disorders and manifestation of pesticide/xenobiotic toxicity.

It could take several years for a disorder to manifest itself and no one would think of linking a chronic neurological disorder with pesticide toxicity, eg, OPIDN. Women breast-feeding their babies can transmit toxic pesticide residues to the child.

Medical research in the field of pesticide toxicology has gained momentum since the 1980s and 1990s. A few institutions in collaboration with medical colleges, have tried to document such work in human cases and reproduced similar dysfunctions in experimental animals (King George's Medical College and Industrial Toxicology Research Centre, Lucknow).

Unfortunately, there is no National Medical Registry of diseases caused by pesticides which could contain records from all states to be fed into a central computer-network so that data generated from medical colleges and hospitals would be accurate and clinically proven. We need far more epidemiological studies. However, the greatest difficulty faced by medical persons is that prevention is not taken seriously by consumers and the general public. The need for reorganizing medical curricula to sensitize medical students and doctors about environmental hazards to health; better epidemiological data/statistics, along with the use of media/TV to educate the public in the prevention of disease through the safe use of common pesticides, are essential.

Dr. Devika Nag, *former Professor and Head of the Neurology Department, King George Medical College, Lucknow.*

Malathion Fogging and Its Health Hazards

Dr. V. P. Sharma

In the 1970s, thermal fogging machines of various makes were imported by the National Malaria Eradication Programme (NMEP) to fight the Japanese Encephalitis (JE) epidemics that broke out in several parts of the country. Thermal malathion fogging gradually found application in the control of urban malaria. Since then, it has become a routine procedure in the control of malaria in urban areas. However, high malaria transmission and JE epidemics, and dengue haemorraghic fever epidemics are now increasing in the country. In 1996, the DHF epidemic in Delhi was responsible for more than 9000 cases and over 400 deaths.

To combat the growing mosquito nuisance and control malaria and JE epidemics, demand for the thermal malathion fogging is increasing in the municipal and industrial areas of the country. A study on the impact of thermal malathion fogging revealed that the mortality of mosquitoes exposed to the malathion fog in wire mesh cages was very low and varied from 0 to 58 per cent; however, in thickly populated areas, fogging killed 50 per cent of the caged mosquitoes. In localities where mosquitoes were held beyond a five metre distance on the second or higher floors, there was no mortality of the caged mosquitoes.

It was concluded that *thermal malathion fogging was ineffective in the control of disease vectors and mosquitoes responsible for these vector-borne diseases and its discontinuation as a routine method of malaria control was recommended to the Ministry of Health, Government of India.*

It may be noted that dengue haemorraghic fever control in Delhi was largely the result of source reduction, larviciding, implementation of legislative measures, and information, education and communication, and not the fogging which was in demand due to its visibility.

With the increase in demand of malathion fogging and occasional reports of adverse reactions, by some individuals, there is a growing concern in some sections of society on the health hazards of the fogging.

In thermal malathion fogging, technical grade malathion (more than 97 per cent purity) is mixed with diesel oil and the fogging machine is adjusted so as to produce a fog with a particle size of less than 25 micron. Malathion breaks down to malaxon, which is highly toxic. Malathion inactivates acetylcholinesterase, an enzyme which removes neurotransmitter acetylcholine in patients with respiratory and cardiac problems. The presence of excessive acetylcholine may precipitate a crisis by aggravating symptoms. In addition, the toxicity of diesel may further aggravate the symptoms of malathion toxicity. Poisoning by malathion or other organophosphorus and carbamate groups of compounds, impede coherent nerve impulse, and when a large number of neurons are affected, it leads to symptoms of poisoning, which include twitching, tingling, tremors, convulsion, seizures and death.

During the fogging operation, the entire community is exposed to the malathion fog. Although the acute toxicity of the fog may be within the safety limits of healthy persons, its effect on patients such as those suffering from respiratory, allergic and cardiac diseases has not been established. *In view of the possible adverse health hazards, it is advisable to stop malathion fogging in vector control.*

Dr. V.P. Sharma, *former Director of Malaria Research Centre, is presently a consultant with the World Health Organisation.*

PESTICIDE HANDBOOK

Pesticide Usage in India

Pesticide use began in India in 1948 when DDT was imported for malaria control and BHC for locust control. In 1949, both the pesticides, DDT and HCH (BHC), began to be used in agriculture. Soon other organochlorine insecticides like chlordane, heptachlor, dieldrin, aldrin and endrin were being used. These were followed by organophosphorous insecticides like malathion, diazinon and phorate and those of the carbamate group like carbaryl. India began pesticide production in 1954 with a manufacturing plant for DDT and HCH (incidentally, the DDT plant was a gift from the World Health Organisation). In 1958, India was producing over 5,000 metric tonnes of pesticides, especially insecticides, like DDT and HCH. In the mid-nineties, the production was 96,500 metric tonnes. Even today, the bulk of the pesticide production is insecticides, although manufacture of fungicides, herbicides and rodenticides have started in the country. In the 80s, large-scale use of synthetic pyrethroids had begun in the country. India is presently the second largest manufacturer of basic pesticides in Asia. It ranks 12th globally.

Currently, India consumes about 75,417.70 metric tonnes of pesticides annully for agricultutral purposes. Despite such a large cosumption of pesticides, it is estimated that crop losses vary between 10 to 30 per cent in India, depending on the crop and the region. In monetary terms, these losses amount to Rs 290,000 million per year.

Indiscriminate usage of pesticides has led to environmental contamination as well. Pesticides like DDT and HCH which were extensively used because of their broad spectrum toxicity, have entered the food chains and accumulated in all living forms, including humans, and affected the normal functioning of living organisms. In the mid 70s, DDT had been banned in Europe and USA. Many other pesticides like endrin, aldrin and dieldrin too were banned because of their undesirable properties. In India, DDT was banned for agriculture only in 1989. Likewise, other pesticides have also been banned for usage and manufacture in India, some due to the resistance developed by pests, or due to issues concerning environmental contamination as well as international pressure. However, there is no alternative pest management plan in place, the trend has been towards replacing one class of chemicals with the other, like organochlorines being replaced with organophosphates and synthetic pyrethroids. Even after 10 years, when India officially adopted the programme (in 1990), the concept of Integrated Pest Management has not taken off very well, though it promotes an environmentally sound and sustainable strategy of pest control.

Table 1. List of Insecticides Registered on a Regular Basis Under Section 9(3) of the Insecticides Act, 1968 in India

S.No.	Name of insecticide
1.	Acephate
2.	Alachlor
3.	Aldicarb
4.	Allethrin
5.	Alphanapthyl acetic acid
6.	Aluminium phosphide
7.	Anilophos
8.	Atrazine
9.	Alphacypermethrin
10.	Aureofungin
11.	Barium carbonate
12.	Benzene hexachloride (BHC)
13.	Benthiocarb (Thiobencarb)
14.	Benomyl
15.	Bitertanol
16.	Bromadiolone
17.	Butachlor
18.	Calcium cyanide
19.	Captafol
20.	Captan
21.	Cartap hydrochloride
22.	Carbaryl
23.	Carbendazim
24.	Carbofuran
25.	Carboxin
26.	Chlorobenzilate
27.	Chlorfenvinphos
28.	Chlormequat chloride (CCC)
29.	Chlorothalonil
30.	Chlorpyriphos
31.	Copper oxychloride
32.	Copper sulphate
33.	Coumachlor
34.	Coumatetralyl
35.	Cuprous oxide
36.	Cypermethrin
37.	Cyfluthrin
38.	Dalapon
39.	Decamethrin/ Deltamethrin
40.	Dichlorodiphenyl itrichloroethane (DDT)
41.	Dichloropropane and dichloropropenes mixture (DD mixture)
42.	Dichlorvos (DDVP)
43.	Dicofol
44.	Diflubenzuron
45.	Dimethoate
46.	Dinocap
47.	Dioxathion
48.	Diuron
49.	Dodine
50.	Diazinon
51.	Dieldrin
52.	2,4–Dichlorophenoxy acetic acid (2,4–D sodium amine and ester salts)
53.	Ethylene dibromide
54.	Edifenphos- carbon tetrachloride mixture (EDCT Mixture3:1)
55.	Endosulphan
56.	Ethofenprox / Etofenprox
57.	Ethephon
58.	Ethylene dibromide (EDB)
59.	Ethyl mercury chloride
60.	Ethion
61.	Fenitrothion
62.	Fenarimol
63.	Fenobucarb (EPMC)
64.	Fenthion
65.	Fenvalerate
66.	Ferbam
67.	Fluchloralin
68.	Fluvalinate
69.	Formothion
70.	Fosetyl- Al
71.	Gibberellic acid
72.	Glyphosate
73.	Iprodione
74.	Isoproturon
75.	Kitazin
76.	Lime sulphur
77.	Lindane (Gamma BHC)
78.	Malathion
79.	Maleic hydrazide (MH)
80.	Mancozeb
81.	Menazon
82.	Metaldehyde
83.	Methabenzthiazuron
84.	Methoxy ethyl mercury chloride (MEMC)
85.	Methyl bromide
86.	Methyl bromide + Ethylene dibromide (1:1 & 3:1)
87.	Methyl chlorophenoxy acetic acid (MCPA
88.	Metalaxyl
89.	Metoxuron
90.	Methomyl
91.	Metribuzin
92.	Methoxychlor
93.	Monocrotophos
94.	Mono sodium methane arsinate (MSMA)
95.	Myclobutanil
96.	Methyl parathion
97.	Nickel chloride
98.	Nicotine sulphate **
99.	Oxadiazon
100.	Oxycarboxin

contd.

contd.

S.No.	Name of insecticide	S.No.	Name of insecticide
101.	Oxydemeton-methyl	123.	Sodium cyanide
102.	Oxyfluorfen	124.	Streptomycin
103.	Para dichlorobenzene	125.	Sulphur
104.	Paris green (Copper acetoarsenite)	126.	Temephos
105.	Paraquat dichloride	127.	Trichloro acetic acid (TCA)
106.	Pendimethalin	128.	Triallate
107.	Permethrin	129.	Trichlorphon
108.	Phenthoate	130.	Tricyclazole
109.	Phenylmercury acetate (PMA)**	131.	Tridemorph
110.	Phorate	132.	Trifluralin
111.	Phosalone	133.	Thiometon
112.	Phosphamidon	134.	Thiram
113.	Primiphos methyl	135.	Thiophanate methyl
114.	Profenophos	136.	Triazophos
115.	Propanil	137.	Triadimefon
116.	Propetamphos	138.	Warfarin
117.	Propoxur	139.	Zinc phosphide
118.	Pyrethrum	140.	Zineb
119.	Quinalphos	141.	Ziram
120.	Sevidol (4: Carbaryl and Gamma HCH)	142.	Hexaconazole
121.	Simazine	143.	Pretilachlor
122.	Sirmate	144.	Propiconazole

** for export only

Source: *Pesticide Information, Vol. XXIV:*

Table 2. Production of Basic Pesticides in India

Year	Production in tonnes/annum
1955-56	2,836
1960-61	8,448
1965-66	13,951
1973-74	32, 745
1978-79	52,528
1988-89	61,100
1989-90	65,800
1990-91	74,300
1991-92	72,809
1992-93	76,933
1993-94	83,428
1994-95	90,758
1995-96	96,500
1996-97	1,02,740
1997-98	1,02,240*

Note: **anticipated values*

Source: *Pesticide Information, Vol. XXIV: No. 4; pp 9–21.*

Consumption Pattern of Pesticides

In India, 75 per cent of the pesticides used are insecticides like the organochlorines, organophosphorus group, carbamates, synthetic pyrethroids and other groups. The remaining 25 per cent include mostly fungicides, followed by herbicides and other groups of pesticides. In contrast, the worldwide consumption indicates that herbicides constitute 47 per cent of the total pesticides used all over.

Fig 1: Consumption Pattern of Pesticides in India

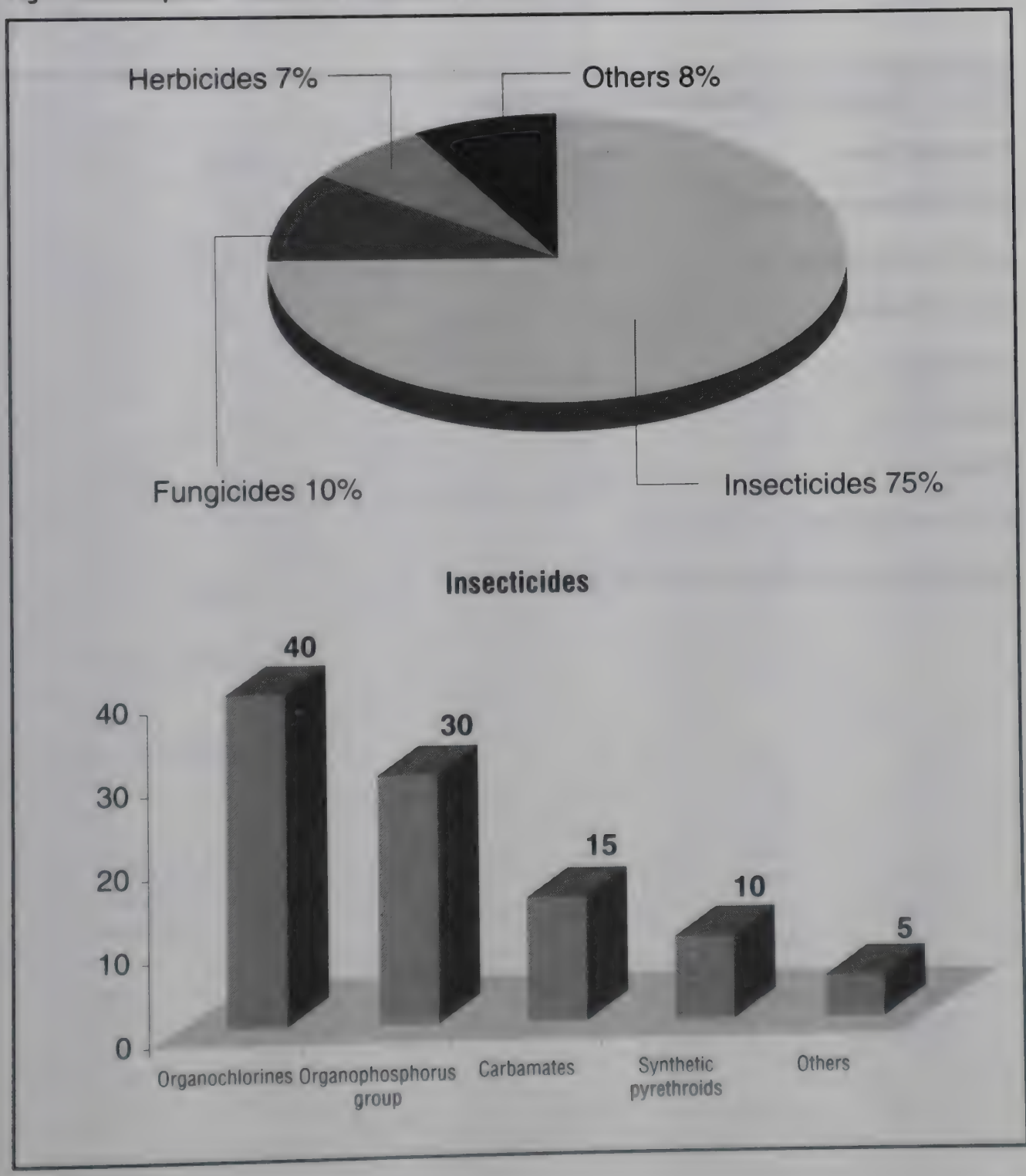


Table 3. Percentage Consumption of different Pesticides

Pesticides	Consumption (%)	
	World	India
Herbicides	47.5	15.76
Insecticides	29.5	80.45
Fungicides	17.5	1.46
Others	5.5	2.33

Table 4. Agrochemical Market by Chemical Class

Chemical Class	India	World
Organophosphorous group	50	37
Synthetic pyrethroids	19	22
Organochlorines	16	6
Carbamates	4	23
Biopesticides	1	12
Others	10	0

Note: *% total consumption in value terms.*

Source: *Pesticide Information, Vol. XXIV: No. 4; pp 9–21.*

Table 5. Demand Pattern of Pesticides (Techincal Grade) for Agriculture (MT.TECHNICAL)

	Consumption 1995–96	Consumption 1996–97	Actuals 1997–98	Forecast 1998–99
INSECTICIDES				
Acephate	1700	1900	2550	2700
Aldrin	-	-	-	-
Aldicarb	-	-	-	-
Alphamethrin	40	45	68	80
BHC	22000	4250	-	-
BPMC (KL)	100	150	200	225
BT- Sandoz	5	4	5	4
Lupin	23	16	11	15
Wockhardt	-	8	15	15
Biotech	-	8	10	10
Carbaryl	550	400	325	350
Carbofuran	485	410	600	600
Carbosulfan	-	-	-	30
Cartap	5	10	125	200
Chlorpyriphos	1400	1800	2500	3000
Cyfluthrin — 100%	-	-	-	-
Cypermethrin — 100%	1100	1150	1200	1300
Decamethrin — 100%	17	18	22	25
Deltamethrin	-	-	25	-
Diazinon	-	-	90	-
Dichlorovos	1525	1400	1500	1500
Dicofol	210	222	250	250
Dimethoate	1950	1300	1929	1600
Endosulphan	5500	4300	4200	4200
Enthion	1160	1000	1850	2000
Fenitrothion	-	-	-	-
Fenthion	50	50	20	25
Fenvalerate — 100%	1350	1300	1500	1500
Fipronil	-	-	2.5	6
Fluvalinate — 100%	2	1	1	0.5
Folidol Dust	-	-	350	-
Imidacloprid	-	-	-	3.5
Lambda Cyhalothrin – 100%	-	9	13	15
Lindane	40	40	500	500
Malathion	1500	1200	1000	1200
Methomyl	90	120	200	213
Methyl O Demeton — 100%	430	350	400	420
Methyl Parathion — 100%	2400	1700	2000	2100
Monocrotophos — 100%	6900	6500	7500	7500
Phorate	3900	3600	3600	3600
Phosalone	190	230	120	150
Profenophos	50	110	538	600
Temephos	50	60	42	60/50
Triazophos	165	250	645	800
TOTAL	**58,398**	**38,111**	**41,307**	**42,198**

contd.

contd.

	Consumption 1995–96	Consumption 1996–97	Actuals 1997–98	Forecast 1998–99
FUNGICIDES				
Biteranol (KL)	0	1	1	12
Captafol	85	90	110	110
Captan	350	340	450	500
Carbendazim	480	600	650	650
Chlorothalonil	38	42	45	50
Copper Oxychloride	2500	2500	2700	2700
Copper sulphate	–	–	3000	3000
Dinocap	50	22	25	30
Dithionon	–	1	2	2
Dodine	25	30	40	45
Edifenphos — 100%	60	60	75	80
Fenerimol (KL)	10	8	13	10
Fosetyl AL (Mt Formu)	12	23	25	25
Hexaconazole	100	190	18	25
Iprobenfos (IBP)	32	65	150	100
Iprodine	–	–	3	6
Mancozeb	5000	6000	5500	6000
Metalaxyl	9	20	185	185
Myclobutanil	8	1	1	2
Penoconazole	–	–	10	–
Sulphur (W.P)	3000	3300	2500	3000
Sulphur Dust	7000	7000	10000	10000
Thiophanate Methyl	–	65	100	100
Thiram	60	30	62	70
Triadimefon — 100%	25	12	10	11
Tricyclazole	8	40	24	25
Tridemorph	50	250	49	50
Ziram	250	55	275	300
TOTAL	**19,197**	**20,795**	**26,098**	**27,152.2**
HERBICIDES				
2–4, D–Ester (KI)	850	800	800	1400
Salt (T)	1100	1000	1400	1400
Amine (KI)	120	95	100	100
Alachlor – Granule (T)	830	1200	2000	2250
Liquid (KI)	65	50	100	100
Anilophos	500	435	536	600
Atrazine	400	325	400	400
Benthiocarb	15	21	22	2500
Butachlor	2200	2050	2200	2200
Diclofop Methyl	16	10	55	60
Diuron	20	27	31	35
Fluchloralin	150	160	180	180
Glyphosate	210	210	320	500
Isoproturon	2500	2600	2700	2500
Metaxuron	–	–	30	35
Methabenthiozuron — 100%	–	–	–	–
Metribuzin — 100%	22	28	50	55
Oxadiazon	4	8	45	50
Oxyfluorfen	17	15	10	15

contd.

contd.

	Consumption 1995–96	Consumption 1996–97	Actuals 1997–98	Forecast 1998–99
HERBICIDES				
Paraquat (KI)	1400	1400	1400	1600
Pendimethalin	100	139	160	175
Pretilachlor	–	28	140	200
Trifluralin	10	20	165	165
Topic	–	–	–	50
Puma — (KL)	–	–	–	250
Leader	–	–	–	–
TOTAL	**9,468**	**10,651**	**12,919**	**13,960**
RODENTICIDES				
Aluminium Phosphide	900	1050	865	900
Anticoagulant	70	250	250	250
Zinc Phosphide	300	250	230	250
TOTAL	**1,270**	**1,550**	**1,345**	**1,400**
FUMIGANTS				
Ehtylene Dibromide PGR	75	75	75	75
Alfa Naphythyl Acetic Acid	12	13	14	15
Ethephon	8	9	9	10
Gibberellic Acid – Kg	1000	1200	1500	1650
TOTAL	**1,020**	**1,222**	**1,523**	**1,675**
GRAND TOTAL	**89,428**	**72,404**	**83,183**	**86,460.2**

Source: *Pesticide Information, Vol. XXIV: No. 4; pp 9–21.*

Table 6. Consumption of Pesticides in Various States/U.T.S

SL.No.	State/U.T	Consumption (MT)
1.	Andhra Pradesh	9,910
2.	Arunachal Pradesh	30
3.	Assam	595
4.	Bihar	1,700
5.	Gujarat	5,500
6.	Goa	22
7.	Haryana	4,500
8.	Himachal Pradesh	718
9.	Jammu & Kashmir	110
10.	Karnataka	3,900
11.	Kerala	1,100
12.	Madhya Pradesh	4,500
13.	Maharashtra	6,020
14.	Manipur	50
15.	Meghalaya	45
16.	Mizoram	15
17.	Nagaland	12
18.	Orissa	1,800
19.	Punjab	5,770
20.	Rajasthan	2,758
21.	Sikkim	20
22.	Tamil Nadu	12,500
23.	Tripura	164
24.	Uttar Pradesh	8,480
25.	West Bengal	5,000
26.	Andaman & Nicobar	–
27.	Chandigarh	–
28.	Delhi	60
29.	Dadra & Nagar Haveli	4
30.	Daman & Diu	–
31.	Pondicherry	135
32.	Lakshadweep	0.70
	Total	**75,417.70**

Source: *Directorate of Plant Protection and Quarantine, Ministry of Agriculture, Faridabad.*

Table 7. Pesticides Used for Vector Control

	DDT (75%)	DDT(50%)	HCH(50%)	Malathion 25%
1982–83	9000	12000	8163	–
1983–84	5000	11000	7088	–
1984–85	5000	13785	6608	–
1985–86	5000	9832	7786	–
1986–87	5000	15318	7201	–
1987–88	5000	13448	7495	–
1988–89	2500	13556	8048	–
1989–90	–	10657	8764	1800
1990–91	–	11895	8464	1100
1991–92	–	7730	8999	1700
1992–93	–	7525	8072	100
1993–94	–	8750	7479	–
1994–95	–	8182	6305	700
1995–96	–	10550	7584	350
1996–97	–	7606	3204	224
1997–98	–	7889	–	575
1998–99	–	5800	–	2200

Note: *Data on synthetic pyrethroid not included.*
Source: *Sharma V.P., 1998. Malaria Research Centre, Sham Nath Marg, Delhi.*

Table 8. List of Banned Pesticides

SL. No.	Name of pesticides
1.	Dibromochloropropane (DBCP)
2.	Endrin
3.	Pentachlornitrobenzene (PCNB)
4.	Pentachlorophenol (PCP)
5.	Toxaphene
6.	Ethyl parathion
7.	Chlordane
8.	Hepatchlor
9.	Aldrin (w.e.f. 1.1.1994)
10.	Paraquat — di–methyl sulphate
11.	Nitrofen
12.	Tetradifen

Source: *Directorate of Plant Protection and Quarantine, Ministry of Agriculture, Faridabad.*

Table 9. List of Pesticides Not Approved for Use

Sl. No.	Name of Pesticides
1.	Calcium arsonate
2.	EPN
3.	Azinpho–methyl
4.	Mevinphos (Phosdrin)
5.	Lead arsonate
6.	2,4,5–T
7.	Carbophenothion
8.	Vamidothion
9.	Mephosfolen
10.	Azinphos ethyl
11.	Binapacryl
12.	Dicrotophos
13.	Thiodemetera /Dosi
14.	Fention acetate
15.	Fention hydroxide
16.	Chinomethionate
17.	Ammonium sulphamate
18.	Leptaphos (Phosvel)

Source: *Directorate of Plant Protection and Quarantine, Ministry of Agriculture, Faridabad.*

Table 10. List of Pesticides Which are Under Review by Government of India

Sl. No.	Name of pesticides
1.	Alachlor
2.	Benomyl
3.	Copper acetoarsenite
4.	Diuron
5.	Ethyl mercury Chloride
6.	Fenarimol
7.	Menazon
8.	Methomyl
9.	Oxyflourfen
10.	Sodium methane arsonate
11.	Calcium cyanide
12.	Phosphamidon
13.	Thiometon
14.	Triazophos
15.	Tridemorph
16.	Monocrotophos
17.	Ziram
18.	Zineb

Source: *Directorate of Plant Protection and Quarantine, Ministry of Agriculture, Faridabad.*

Table 11. List of Pesticides Restricted for Use in India as on 31.12.1992

Name of Pesticides	Type of Restrictions (s) Imposed
Aluminium phosphide	It is to be sold only to government undertakings/organizations and to be used under the strict supervision of government experts on pest control operations whose expertise is approved by the Plant Protection Adviser to the Govt. of India.
BHC (HCH)	The use of BHC on vegetables, fruits, oilseed crops and in preservation of foodgrain is banned w.e.f. 1.4.1997.
Chlorbenzilate	Use in agriculture is banned. If required, it can be imported by govt. /semi–govt. organizations.
Captafol	Shall be used only as seed dresser. Its use as foliar spray is banned.
DDT	Use of DDT in agriculture is banned. Use of DDT for the public health programme up to 10,000 MTs per annum, except in case of any major outbreak, is restricted.
Dieldrin	Use of dieldrin shall be restricted for locust control in desert areas by Plant Protection Adviser to the Government of India.
Ethylene dibromide (EDB)	Use of EDB shall be restricted as fumigant for foodgrains through Central Government, government undertakings, government organizations, such as Food Corporation of India, Central Warehousing Corporation and pest control operators whose expertise is approved by Plant Protection Adviser to the Govt. of India .
Methyl bromide	Methyl bromide is used as fumigant in the manner in which aluminium phosphide is used.
Sodium cyanide	Use of sodium cyanide shall be restricted to fumigation of cotton bales.
Phenyl mercury acetate (PMA)	Use of PMA is prohibited in India w.e.f. 1.1.73, but it has continued to be produced in the country for export only. Non–consumed stock as on 1.1.73 shall be used for export purpose only and shall be subject to the modification in the Certificate of Registration to this effect.
Lindane	Use of lindane formulations generating smoke for indoor use is prohibited in India, provided that it may be continued to be produced in the country for use in the control of insect pests of field crops and subject to the modification in the Certificate of Registration to this effect.
Nicotine sulphate	Use of nicotine sulphate is prohibited in India, provided that it may be continued to be produced in the country for export purpose only and subject to the modification in the Certificate of Registration

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agrcultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012, p. 22–23.*

Pesticides in Food Commodities

One hundred and twenty five million hectares is under pesticide cover. The use of pesticides in India is increasing at the rate of 2.5 per cent per annum. There are 146 pesticides registered for use and the forecast for pesticide use for 1998–99 was around 86,460.2 metric tonnes. Synthetic pesticides have become very popular with our farmers because of their quick economic returns. The consumption of pesticides in India is 0.57 kg/ha, which is very low compared to 2.0 to 3.0 kg/ha in the USA and Europe. Despite this, there is widespread contamination of our food commodities. The main reason for this is the indiscriminate and non-judicious use of pesticides.

A survey carried out in early 90s by the Indian Council of Medical Research indicated that 51 per cent of our food commodities were contaminated with pesticide residues and 20 per cent of these had pesticides above the maximum residue limit (MRL). In the next multicentric survey carried out by the All India Coordinated Research Projects on Pesticide Residues, it was seen that pesticides were present in almost all food commodities, but there was a drastic decline in the percentage of food commodities with pesticides above the maximum tolerance limits. In a way, it could be interpreted as an improvement in agricultural practices.

It should not be overlooked that the developed countries have begun to lower the maximum permissible limits so as to minimize their health impacts. Also, they have included integrated pest management, organic farming, biopesticides and biotechnology in their agricultural policies.

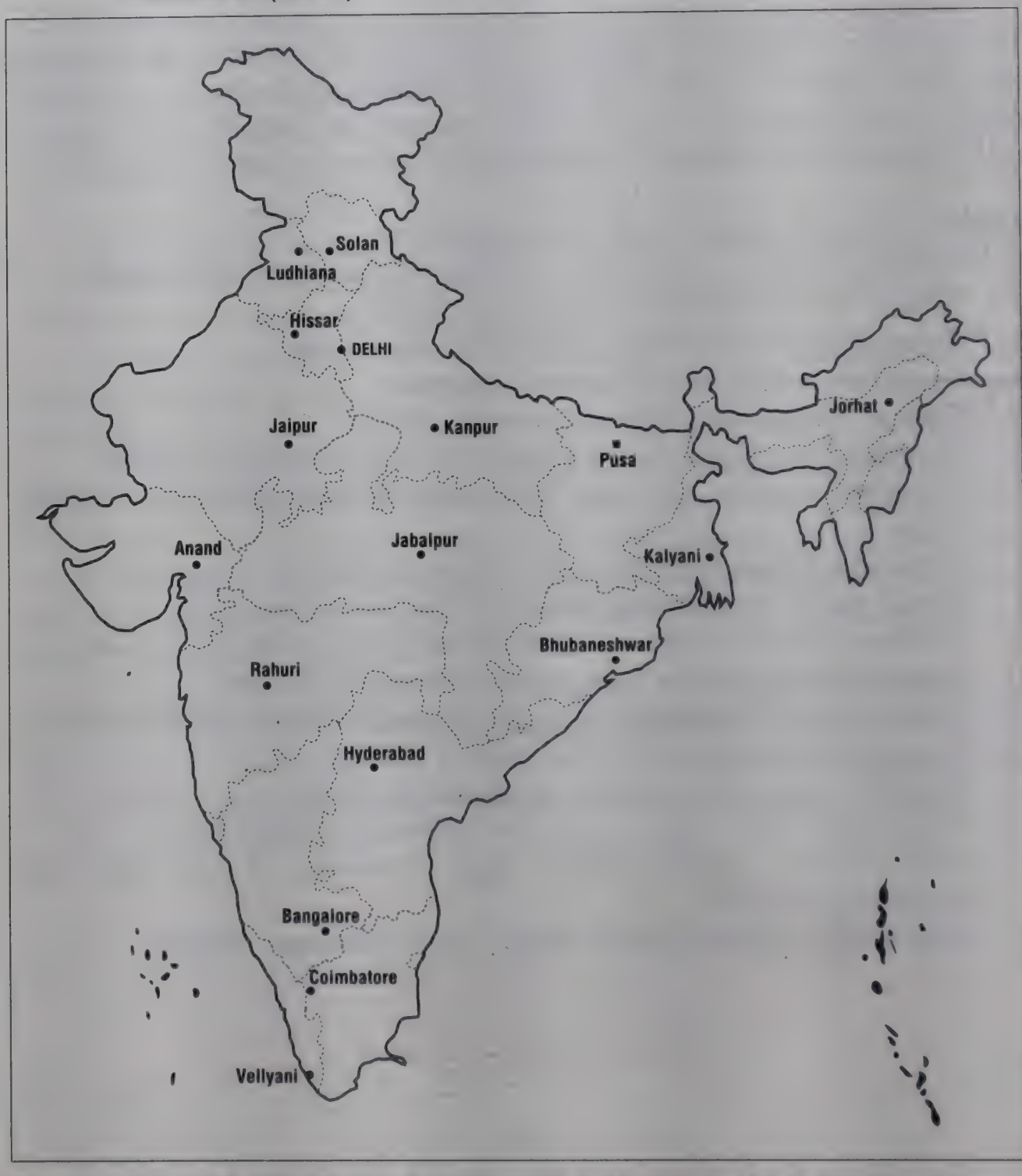
All India Coordinated Research Project (AICRP) on Pesticide Residues

The All India Coordinated Research Project (AICRP) on Pesticide Residues which was initiated in 1986, focused on monitoring pesticides in agricultural produce and evaluating the safe waiting periods for pesticides in crops and recommending to the ministry concerned the tolerance limits of pesticides.

ACRIP centres are located in the following places:

1. Andhra Pradesh: Acharya N.G. Agricultural University, Hyderabad
2. Assam: Assam Agricultural University, Jorhat
3. Bihar: Rajendra Agricultural University, Samastipur
4. Delhi: Indian Agricultural Resarch Institute
5. Gujarat: Gujarat Agricultural University, Anand
6. Haryana: Choudhary Charan Singh Agricultural University, Hissar
7. Himachal Pradesh: Y.S. Pamar University of Horticulture and Forestry, Solan
8. Karnataka: Indian Institute of Horticultural Research, Bangalore
9. Kerala: Kerala Agricultural University, Thiruvananthapuram
10. Madhya Pradesh: Jawaharlal Nehru Krishi Viswa Vidyalaya, Jabalpur
11. Maharashtra: Mahatma Phule Krishi Vidhyapeeth, Rahuri
12. Orissa: Orissa University of Agriculture and Technology, Bhubaneswar
13. Punjab: Punjab Agricultural University, Ludhiana
14. Rajasthan: Rajasthan Agricultural University, Jaipur
15. Tamil Nadu: Tamil Nadu Agricultural University, Coimbatore
16. Uttar Pradesh: Chandra Sekhar Azad University of Agriculture and Technology, Kanpur
17. West Bengal: Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani

Map 1: Pesticide Research Stations Under Indian Council of Agricultural Research Laboratories (ACRIP)



Source: *Agnihothri N.P., 1999. Pesticide Safety Evaluation and Monitoring, All India Coordinated Research Project on Pesticide Residues. Division of Agricultural Chemicals, IARI.*

Contamination of Food Commodities by Pesticides

Studies on contamination of pesticide residues on a worldwide basis indicates that 79 per cent of the food samples tested did not show pesticide residues and only 2 per cent of the remaining 21 per cent, showed pesticides above tolerance limits.

However, in India, in an ICMR study, it was seen that 51 per cent of the food commodities were contaminated with pesticides and 20 per cent of the samples had levels of pesticides exceeding maximum permissible limits. In another study initiated by ICAR which followed later, 60 per cent of the samples were found to be contaminated with pesticides, of which, 14 per cent showed contamination over the tolerance limits.

Fig 2: Pesticidal Contamination of Food Commodities

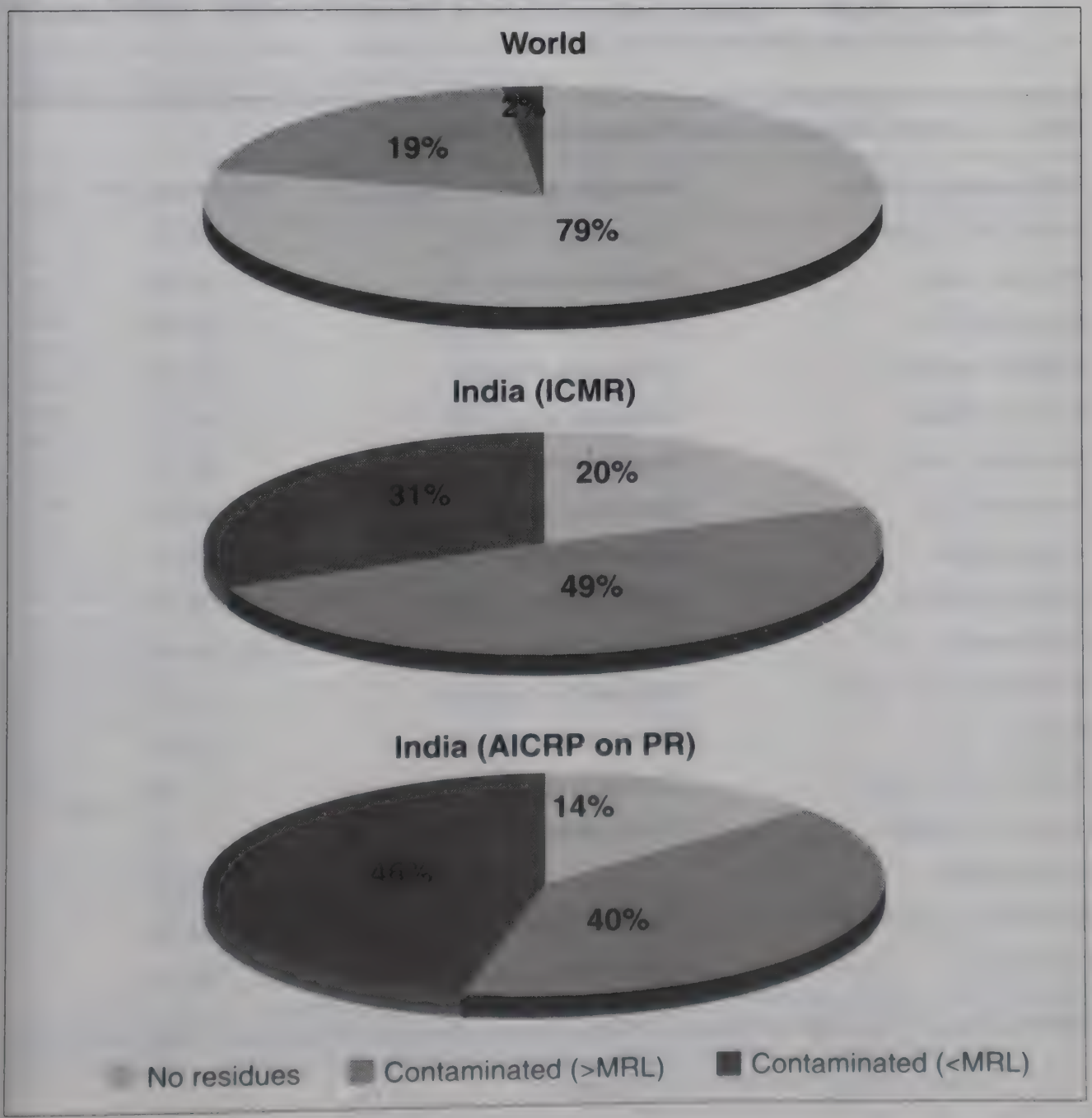


Table 12. Estimated Crop Losses in Important Crops

Crop	Loss (%)	Value (Rs. in million)
Rice	18.6	55,120
Wheat	11.4	14,150
Jowar	10.0	1,732
Pulses	7.0	4,840
Oilseeds	25.0	41,800
Cotton	22.0	20,000
Sugarcane	15.0	13,360

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012, page 9.*

Table 13. Losses Caused by Some Important Insect Pests

Pest common name	Scientific name	Percentage loss
Brown plant hopper	Nilaparvata lugens	10–70
Rice gall midge	Orseolia oryzae	15–60
Rice stem borer	Scirpophaga incertulas	25–30
Sorghum shoot fly	Atherigona soccata	30–60
Sorghum midge	Contarinia sorghicola	30–50
Maize pink borer	Sesamia inferens	25–75
Pulse steam fly	Ophiomyia sp.	50–72
Mustard aphid	Lipaphis erysimi	30–70
Cotton bollworms	Spodoptera sp.& others	50–60
Cotton whitefly	Bemisia tabaci	53–80
Groundnut leaf– miner	Aproaerema modicella	24–92
Safflower aphid	Actynotus carthami	9–67
Sesame leaf webber	Antigastra sp.	40
Castor semilooper	Achea janata	30
Linseed budfly		48
Brinjal fruit & shoot borer	Leucinodes orbonalis	60–80
Chilli midge	Asphordylia capsici	30–50

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012, page 10.*

Table 14. The Consumption of Pesticides and Cropped Area

Crop	Pesticide share (%)	Cropped area (%)
Cotton	52–59	5
Rice	17–18	24
Vegetables & Fruits	13–14	3
Plantation crops	7–8	3
Cereals / oilseeds / pulses	6–7	58
Sugarcane	2–3	2

Source: Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012, page 14.

Table 15. Cropwise Consumption of Pesticides

	Pesticide consumption	
Crop	Estimated (in million Rs.)	Percentage of total
Paddy	1272.05	22.0
Wheat	354.18	6.4
Jowar	495.40	8.9
Bajra	95.05	1.8
Barley	0.00	0.0
Ragi	24.04	0.4
Maize	63.62	1.1
Arhar	155.20	2.8
Gram	12.20	0.2
Jute	15.38	0.3
Cotton	2462.13	44.5
Sugarcane	38.41	0.7
Groundnut	136.84	2.5
Rapeseed and Mustard	9.10	0.2
Soybean	0.95	0.0
Sunflower	3.04	0.1
Onion	10.92	0.2
Potato	2.45	0.0
Tobacco	3.93	0.1
Tapioca	0.10	0.0
Fruits and Vegetables (excluding Onion and Potato)	389.38	7.0
Total	**5556.37**	**100.0**

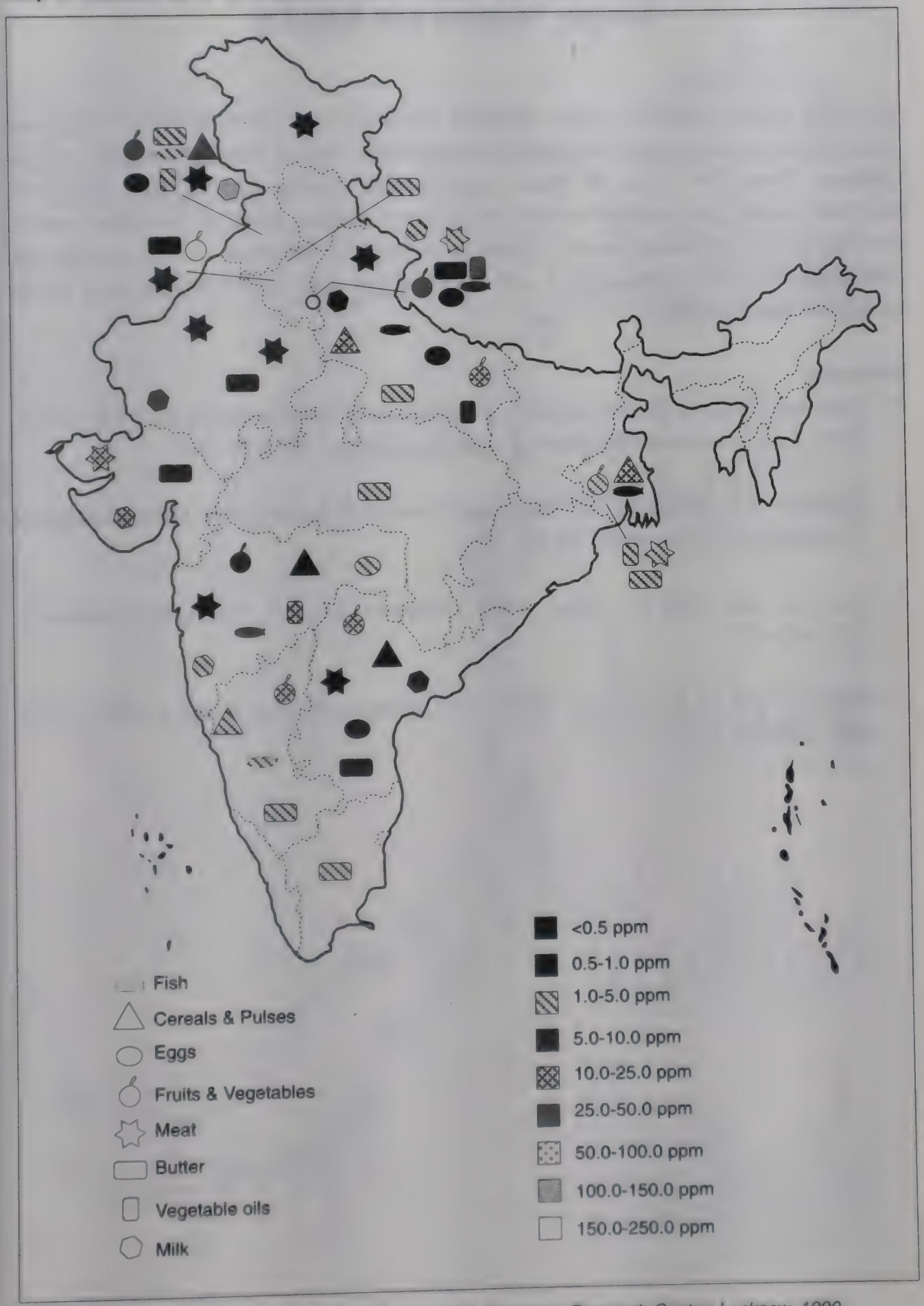
***Source:** Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012, page 14.*

Organochlorine Pesticides in Food Products

(Maximum levels reported)

Organochlorine pesticides are non-biodegradable and ubiquitous. These chemicals enter biological systems and are bioaccumulated. They are released into the blood from their storage depots (fat tissues) during different physiological conditions (pregnancy) or stress like starvation. Most of these chemicals enter the body through food commodities. Among the various food commodities, dairy products have contributed significantly to pesticide contamination since they contain large amounts of fat molecules. The map shows a few states where monitoring of food commodities has been done. In a number of states, such data is not available. Hence, there is a need to conduct monitoring here so as to ascertain the levels of pesticides and take corrective measures.

Map 2: Residue Level of Organochlorine Pesticides in Food Products



Source: *Toxicology Atlas of India: Pesticides. Industrial Toxicology Research Centre, Lucknow, 1990.*

Organochlorine Pesticide Residues in the Waters of the Ganga, Yamuna and Hooghly

The data shows that the upper reaches of these river systems have fairly low pesticide concentration compared to the plains, where there is extensive agriculture. Pesticide 'run-off' from agricultural fields during the monsoon increase pesticide concentrations in the river waters. Most of the river waters are sources of drinking water. There is a need to monitor rivers so that the pesticide content is evaluated and kept within safe limits before it is made available for drinking.

Sources:

- Agnihotri N.P., G. Kulshrestha, V.T. Gajbhive, S.P. Mohapatra and S.B. Singh, 1996. *Environmental Monitoring and Assessment.* 40; 279–280.

- Gajbhive V.T., N. Kalra, S.P. Mohapatra and N.P. Aghnihotri, 1995. Journal of Environmental Systems. 24; 95–110.

- Nair A. and M.K.K. Pillai, 1992. Science of the Total Environment. 121; 145–157.

- Nair, A. and M.K.K. Pillai, 1992. The Science of the Total Environment. 108; 255–59.

Map 3: Organochlorine Pesticide Residues in the Waters of the Ganga, Yamuna and Hooghly

Source: Toxicology Atlas of India: Pesticides. Industrial Toxicology Research Centre, Lucknow, 1990.

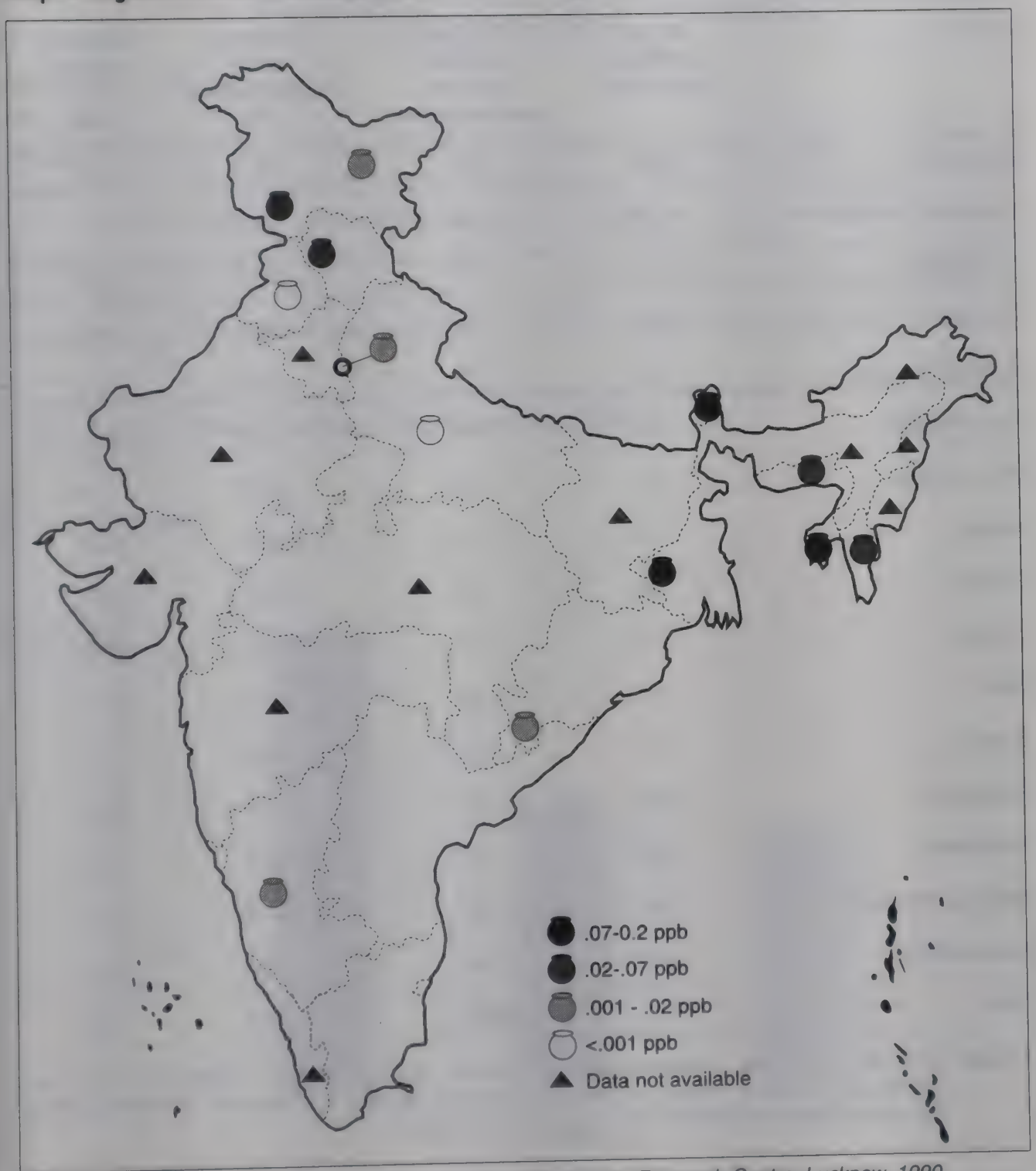
Organochlorine Pesticide Residues in Drinking Water

Monitoring studies have shown that there are residues of organochlorine pesticides in drinking water sources from northeastern parts of India. The pattern of pesticide contamination is at parts per billion value (ppb). Tripura, West Bengal, Sikkim, J&K, Himachal Pradesh, Karnataka, Delhi, Punjab and Uttar Pradesh show pesticides at ranging from 0.1–0.001 ppb levels.

Monitoring studies are still needed in large parts of the country, so as to have a realistic scenario of the pesticide load in drinking water. There is no data from Gujarat, Maharashtra and Kerala, where pesticides are manufactured. Furthermore, our drinking water treatment plants are not equipped to decontaminate pesticides from drinking water. Whatever steps are to be taken should be done before water goes to the treatment plants. Source monitoring and reduction seem to be the best choice for keeping a check on pesticide concentration in water. There is a need to initiate a national monitoring programme on pesticides in drinking water.

Source: Toxicology Atlas of India: Pesticides. Industrial Toxicology Research Centre, Lucknow, 1990.

Map 4: Organochlorine Pesticide Residue in Drinking Water



Source: *Toxicology Atlas of India: Pesticides. Industrial Toxicology Research Centre, Lucknow, 1990.*

Table 16. Contamination of Farmgate Vegetables (Statewise)

Place	No. of samples analyzed	No. of samples found contaminated	Samples with contamination (%)	Samples above MRL (%)
Haryana	1236	697	56.2	4.5
Himachal Pradesh	436	85	19.5	1.4
Tamil Nadu	85	78	91.8	15.3
Gujarat	104	84	80.8	13.5
Andhra Pradesh	275	2	29.8	–
Uttar Pradesh	244	244	100.0	45.9
West Bengal	75	42	56.0	–
Kerala	72	72	100.0	52.8
Punjab	148	86	58.1	4.7
Orissa	105	54	51.4	12.4
Delhi	68	53	77.9	–
Assam	32	15	46.9	–
Rajasthan	388	207	53.4	12.1
Karnataka	370	73	19.7	7.3
Madhya Pradesh	195	189	96.9	1.5
Maharashtra	278	204	73.4	13.7
Total	**4111**	**2265**	**55.1**	**9.5**

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012; page 94.*

Contamination of Farmgate Vegetables (Regionwise)

In vegetable and fruit samples collected from 16 states in India, the states of Tamil Nadu, Uttar Pradesh, Kerala and Madhya Pradesh showed over 80 per cent of the samples contaminated with pesticides. Haryana, West Bengal, Punjab, Orissa, Delhi, Rajasthan, Maharashtra had pesticide contamination in 50 to 80 per cent of the samples. The states of Himachal Pradesh, Andhra Pradesh and Karnataka had pesticidal contamination below 50 per cent.

Fig 3: Contamination of Farmgate Vegetables (Regionwise)

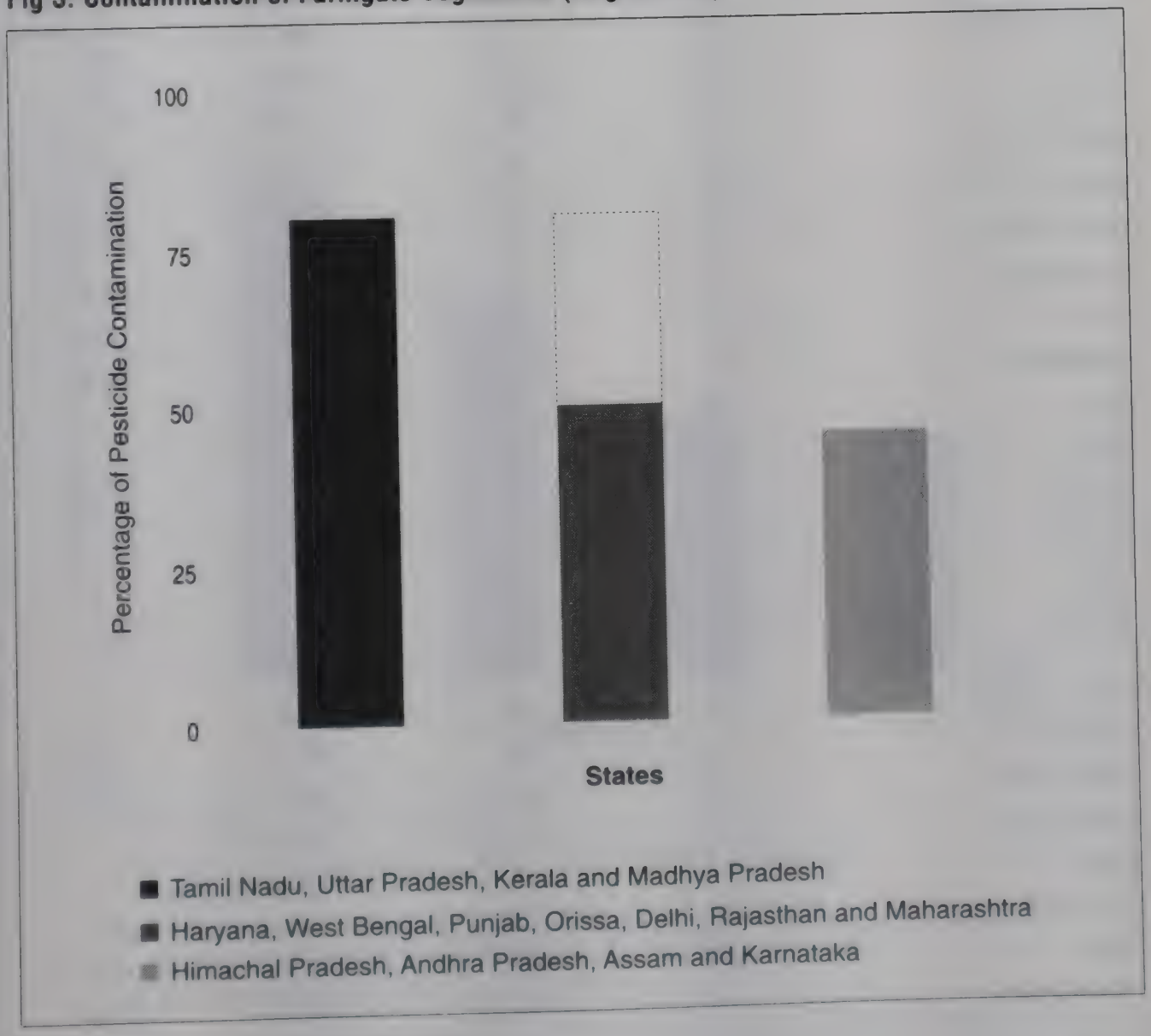


Table 17. Contamination of Vegetables by Pesticides (Cropwise)

Name of vegetable	No. of samples analyzed	No. of samples found contaminated	Samples with contamination (%)	Samples above MRL (%)
Tomato	598	271	45.3	5.4
Cucumber	186	97	52.1	6.5
Palak	39	10	25.6	–
Apple	142	26	18.3	–
Okra	468	281	60.0	15.8
Cabbage	302	189	62.6	7.0
Smooth gourd	81	52	64.2	–
Pointed gourd	15	7	46.7	–
Brinjal	843	493	58.5	9.8
Capsicum	124	39	31.5	12.1
Indian beans	22	16	72.7	9.1
Bitter gourd	125	82	65.6	6.4
Ridge gourd	46	22	47.8	–
Pea grains	161	77	47.8	7.5
Potato	219	137	62.6	9.6
Cauliflower	376	249	66.2	16.8
Peas	20	13	65.0	–
Beans	8	5	62.5	–
Spinach	40	34	85.0	7.5
Mustard	12	5	41.7	–
Parbol	10	5	50.0	–
Cowpea	55	45	81.8	32.7
Cluster beans	24	12	50.0	4.2
French beans	51	9	17.6	15.7
Bottle gourd	33	15	45.4	3.0
Snake gourd	36	29	80.5	19.4
Little gourd	13	10	76.9	–
Carrot	14	8	57.1	–
Fenugreek	12	5	41.7	8.3
Tinda	24	10	41.7	4.2
Pigeonpeas	12	12	100.0	58.3
Total average	**4111**	**2265**	**55.1**	**9.5**

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012; page 95.*

Contamination of Farmgate Vegetables (Vegetablewise)

Among the different types of vegetables, over 80 per cent of the samples of spinach, cowpea and snake gourd showed pesticide contamination, while among vegetables like potato, cabbage, cauliflower, okra, peas, beans, bitter gourd, it was between 60 to 80 per cent contamination. Tomato, mustard, carrot, cucumber, brinjal showed 40 to 60 per cent contamination. The samples of chillies, apples and French beans had below 38 per cent contamination.

Fig 4: Contamination of Farmgate Vegetables (Vegetablewise)

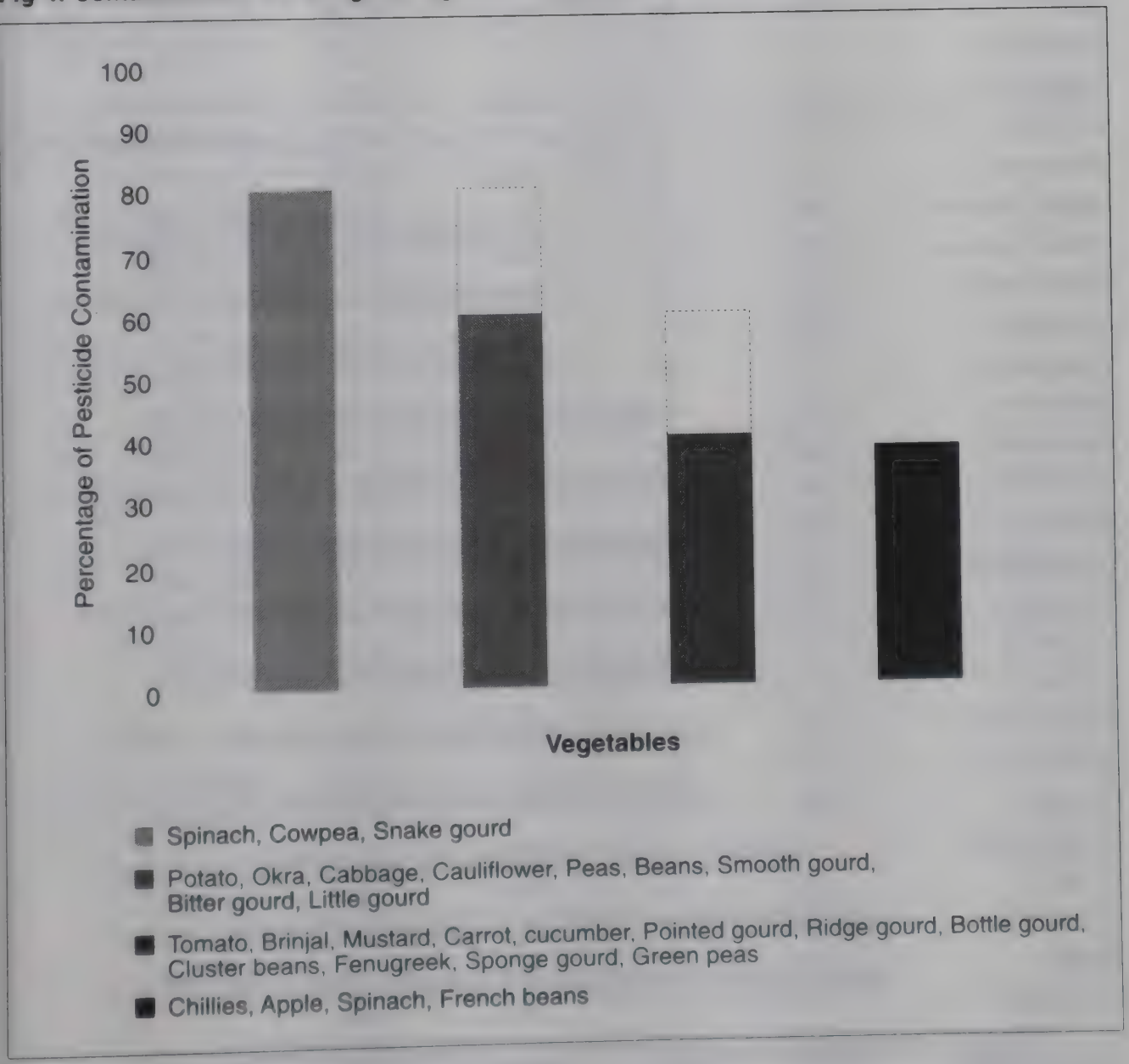


Table 18. Contamination of Vegetables by Pesticides (Pesticidewise)

Pesticides	No. of samples analyzed	No. of samples found contaminated	Samples with contamination (%)	Mean (mg/Kg)	Range (mg/kg)	Samples above MRL (%)
Aldrin	114	39	34.2	0.03	ND–0.08	–
DDT	201	85	42.3	0.10	ND–1.09	–
Endosulphan	422	332	78.9	0.82	ND–18.63	14.0
HCH	777	447	57.5	0.37	0.01–10.86	0.6
Lindane	109	105	96.3	0.15	0.01–0.63	9.2
Chlorpyriphos	86	54	62.8	0.05	0.01–0.89	5.8
DDVP	83	65	78.3	0.20	ND–1.17	26.5
Dimethoate	214	150	70.1	0.68	ND–2.90	6.5
Fenitrothion	79	51	64.6	0.05	ND–0.17	–
Malathion	106	37	34.9	0.23	ND–2.50	0.9
Metasystax	5	5	100.0	0.04	0.01–0.18	–
Methyl parathion	65	54	83.1	0.29	0.02–0.96	30.8
Monocrotophos	470	293	62.3	0.60	0.01–2.45	31.3
Phosphamidon	89	32	35.9	0.29	0.01–3.70	13.5
Quinalphos	253	118	46.6	0.19	ND–6.52	7.9
Cypermethrin	161	80	49.7	0.51	ND–2.49	11.2
Deltamethrin	121	41	33.9	0.07	0.01–1.02	3.3
Fenvalerate	199	103	51.8	0.78	ND–13.60	8.5
Permethrin	54	11	20.4	0.07	ND–0.35	1.9
Mancozeb	120	38	31.7	2.38	ND–9.66	–
Carbendazim	76	13	17.1	1.00	ND–1.95	3.9
Triazophos	39	19	48.7	0.06	ND–1.19	–
Fluvalinate	7	6	85.7	0.04	0.01–0.01	–
Carbaryl						
Pendimethilin	3	1	33.3	0.20	–	–
Carbofuran	118	45	38.1	0.12	ND–0.44	9.3
Phorate	26	25	96.2	0.25	0.03–0.44	23.1
Propiconazole	1	1	100.0	0.04	–	–
Dicofol	2	2	100.0	0.91	0.83–0.91	–
Cyhalothrin	3	3	100.0	0.07	ND–0.22	–
Copper	38	12	31.6	37.50	ND–75.00	15.8
Isoproturan	3	1	33.3	0.02	–	–
Total average	**4111**	**2265**	**55.1**	**0.70**		**9.5**

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012; page 96.*

Contamination of Farmgate Vegetables (Pesticidewise)

Different pesticides used in agriculture were monitored to see which ones could be detected most in vegetables. The vegetables samples taken showed maximum contamination with lindane, followed by endosulphan and DDVP — an organophorous insecticide. The least contamination was with deltamethrin — a synthetic pyrethroid. (Fig 5)

In a study sponsored by ICAR (ACRIP on Pesticide Residues) a total of 4,111 farmgate vegetable samples were tested in 16 states to see the level of contamination with pesticide residues. Results showed that 55.1 per cent of the samples were contaminated with pesticides and 9.5 per cent had pesticide residues exceeding their tolerance limits. (Fig 6)

Fig 5: Pesticide Contamination of Farmgate Vegetables

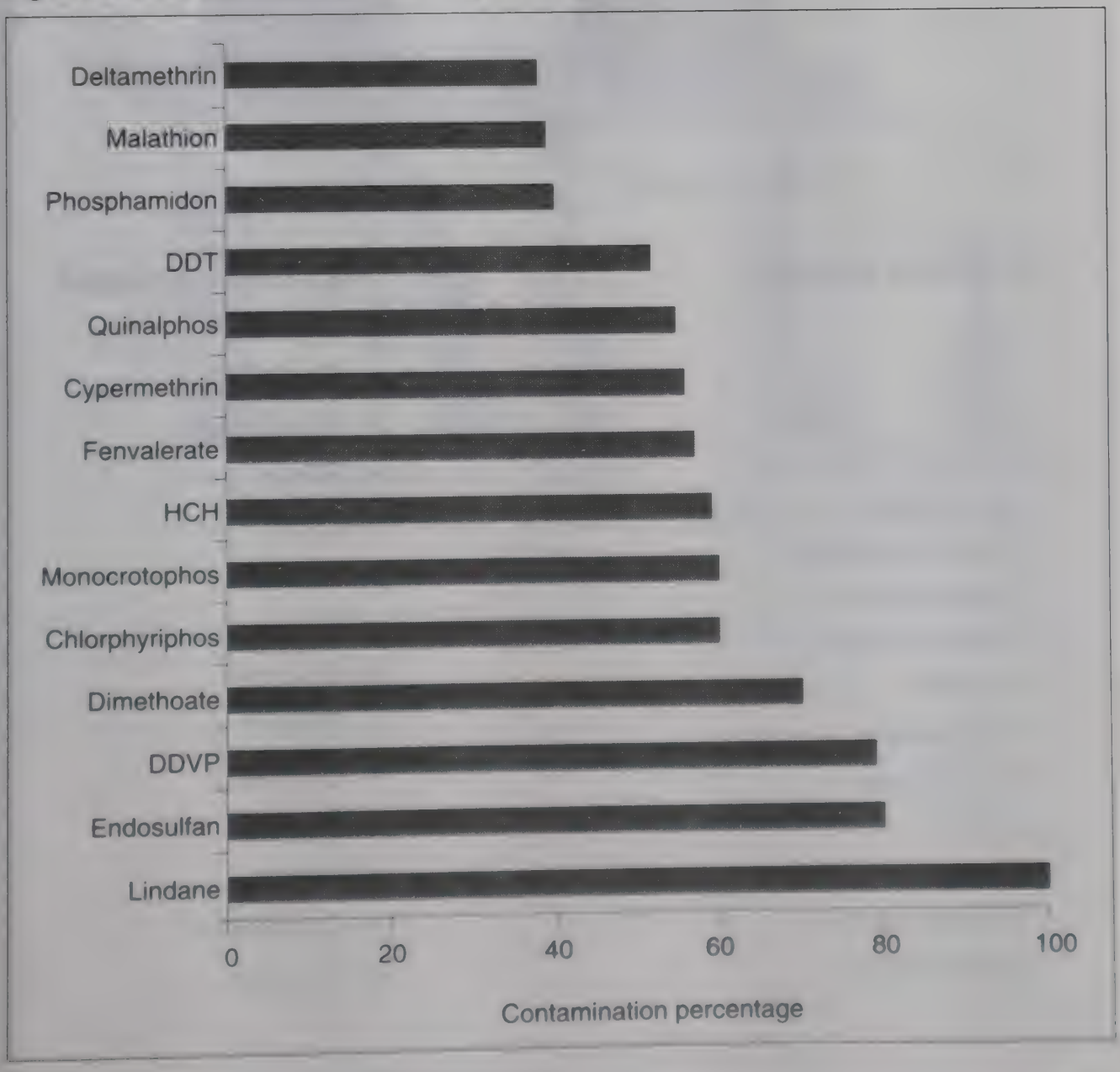
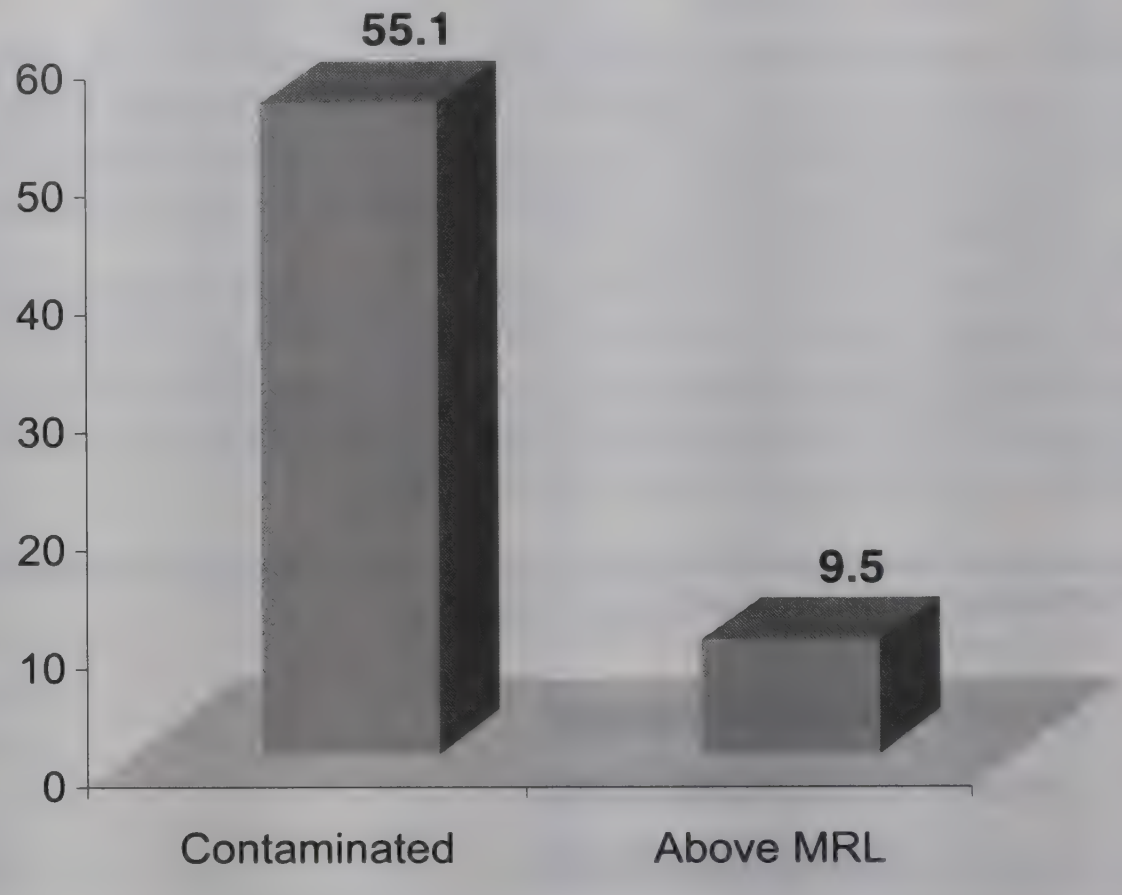


Fig 6: Pesticidal Contamination of Farmgate Vegetables



Pesticides analyzed

- HCH
- DDT
- Endosulphan
- Quinalphos
- Monocrotophos
- Chlorpyriphos
- Phosphamidon
- Lindane
- Fenvalerate
- Dimethoate
- DDVP
- Malathion
- Cypermethrin
- Deltamethrin

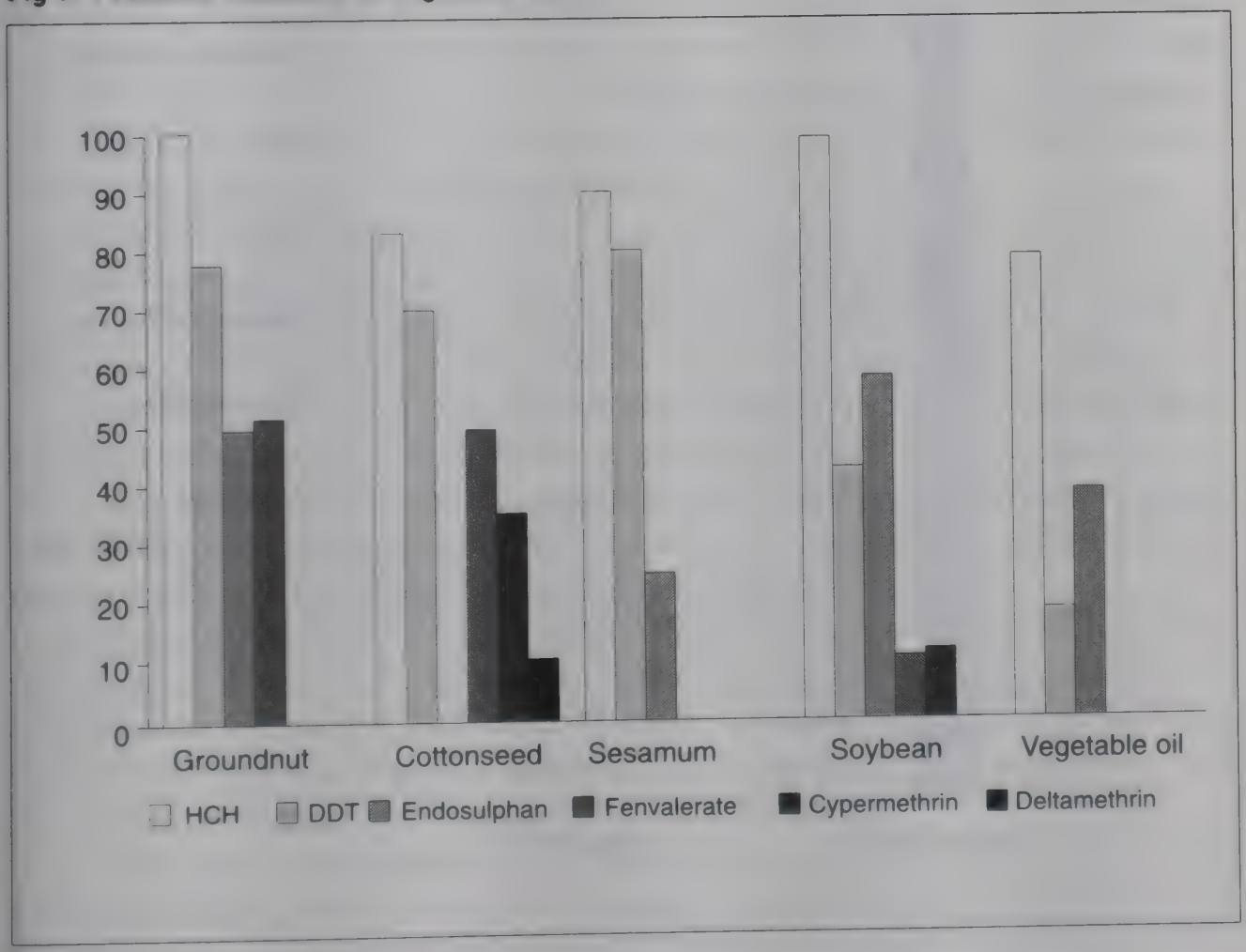
Vegetables analyzed

- Cabbage
- Cauliflower
- Brinjal
- Okra
- Potato
- Beans
- Gourds
- Tomato
- Chillies
- Spinach
- Carrot
- Cucumber
- Cowpea

Pesticide Residues in Vegetable Oils

Samples of groundnut, cottonseed, sesamum, soybean and other vegetable oils were collected from oil mills, dealers and retailers and analyzed for DDT, HCH, endosulphan and synthetic pyrethroids like cypermethrin, deltamethrin and fenvalerate. In the oil samples, HCH and DDT were present in all the samples. Except for cottonseed oil samples, all other types of samples showed pesticide residues below tolerance limits.

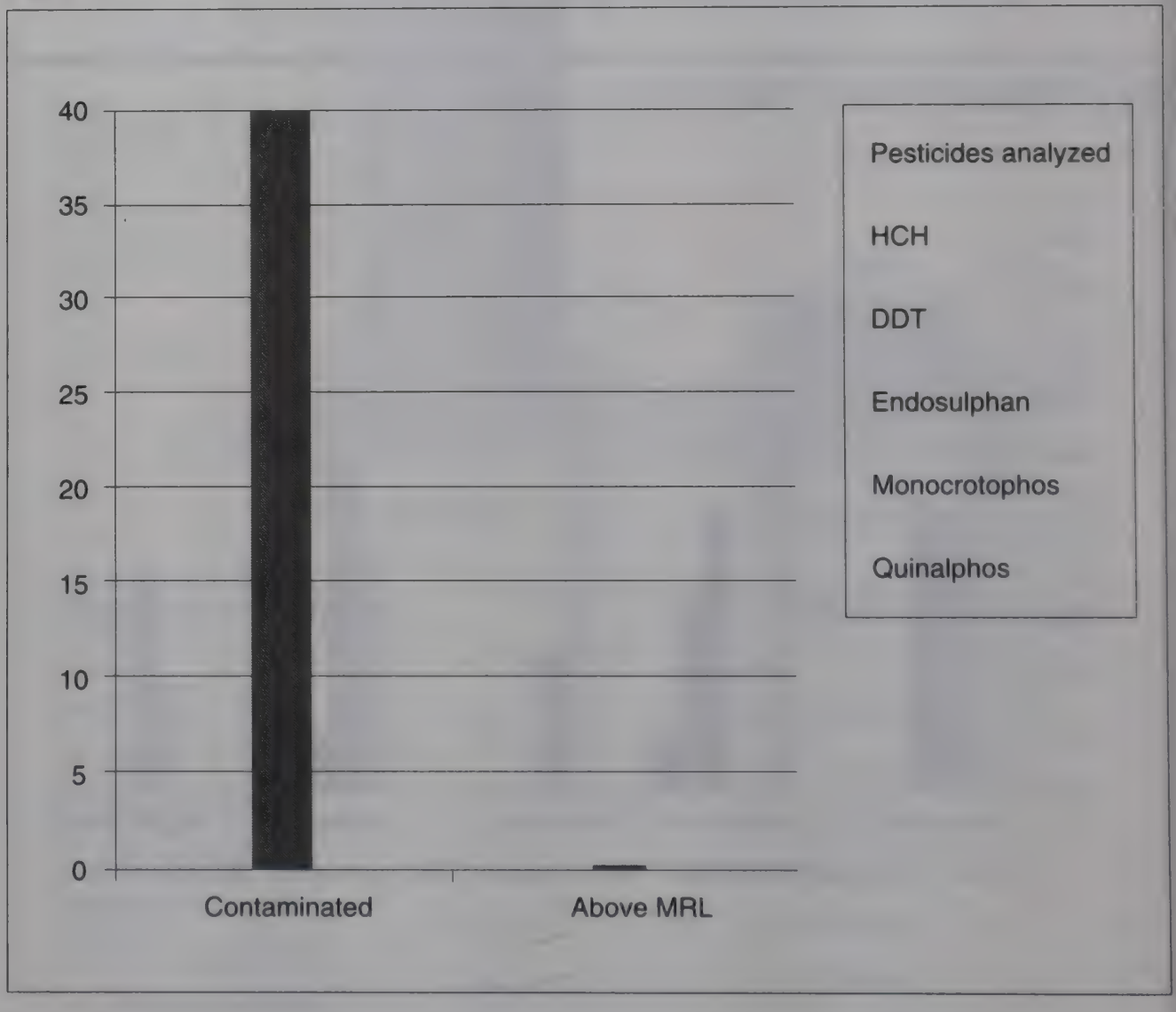
Fig 7: Pesticide Residues in Vegetable Oils



Pesticidal Contamination in Fish Samples

Fish samples were tested from Kerala, Andhra Pradesh and Assam for HCH, DDT, endosulphan, monocrotophos and quinalphos. Among the samples, 40 per cent of samples showed pesticide contamination. None of the samples showed any pesticide exceeding the maximum residue limit.

Fig 8: Pesticidal Contamination of Fish Samples



Contamination of Milk and Milk Products

The major route of pesticide contamination of DDT and HCH to humans is through dairy products. The contamination of milk is mainly through feed, fodder and sometimes due to the use of pesticides in vector control programmes. Insecticides are sprayed in animal sheds so as to keep them free from pests. These are either inhaled by the animal or even enter through the skin into the animal body. DDT and HCH are soluble in fat, hence tend to accumulate in fatty tissues and are slowly secreted into the milk. The pesticide HCH was the most widely used prior to its ban. It is made up of four isomers (compounds with the same molecular weight but differing structures) called the alpha–, beta–, gamma– and delta–HCH respectively. The beta–HCH isomer comprises only 10 per cent when this material is made available in the market. The alpha and the gamma are capable of getting converted into this isomer and increasing their percentage to threefold. The beta–HCH is a carcinogen and its presence is a matter of concern.

The ICMR study on bovine milk from 12 states in the mid 80s found the state of Andhra Pradesh had the highest average of DDT, followed by Punjab. However, in Maharashtra most of the samples tested exceeded the permissible limits of DDT in bovine milk, followed by Punjab and Andhra Pradesh. In the same study, involving 2205 bovine milk samples, 1874 samples were contaminated with beta–HCH and almost 50 per cent (933) of the samples had levels of this isomer above the permissible limits. Among the various samples from different states, samples from Bihar had the highest percentage exceeding the limits for this isomer, while Maharashtra had the least.

In a later study, conducted by ICAR, which was called the AICRP (All India Coordinated Research Projects) on Pesticides Residues, it was found that over 80 per cent bovine milk from 14 states showed DDT and HCH residues and 43.2 per cent showed DDT above tolerance limits, while a staggering 77.8 per cent showed HCH above maximum residue limits.

As milk gets concentrated by churning, the concentration of pesticides increase. Hence, *ghee* is more concentrated with pesticides than butter and butter more than *lassi* with milk having the least. Since, milk itself shows DDT and HCH exceeding the limit values, it would be easy to comprehend the levels in other concentrated milk products.

Fig 9: Pesticidal Contamination in Milk Samples

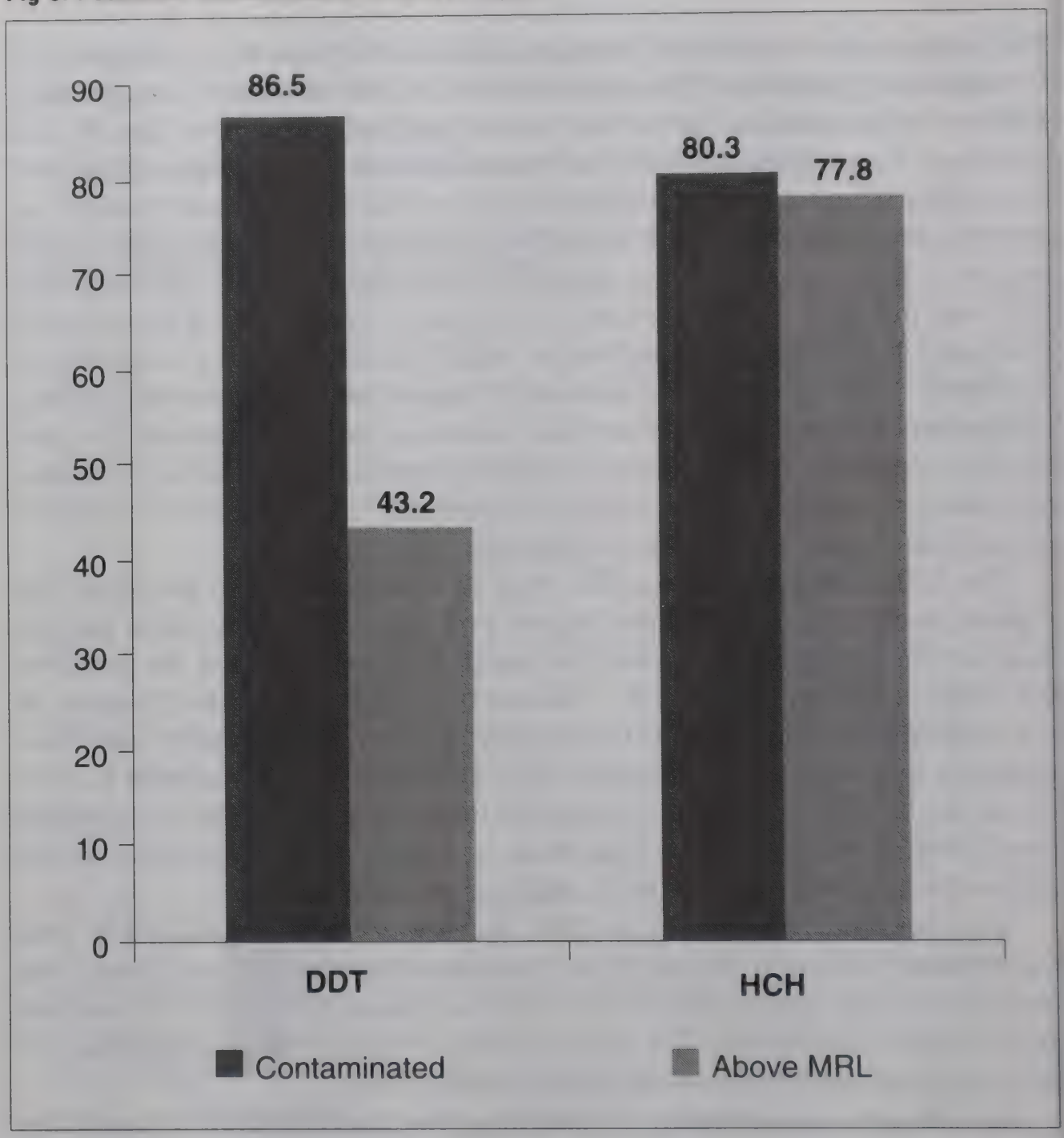


Fig 10: HCH Contamination in Milk Products

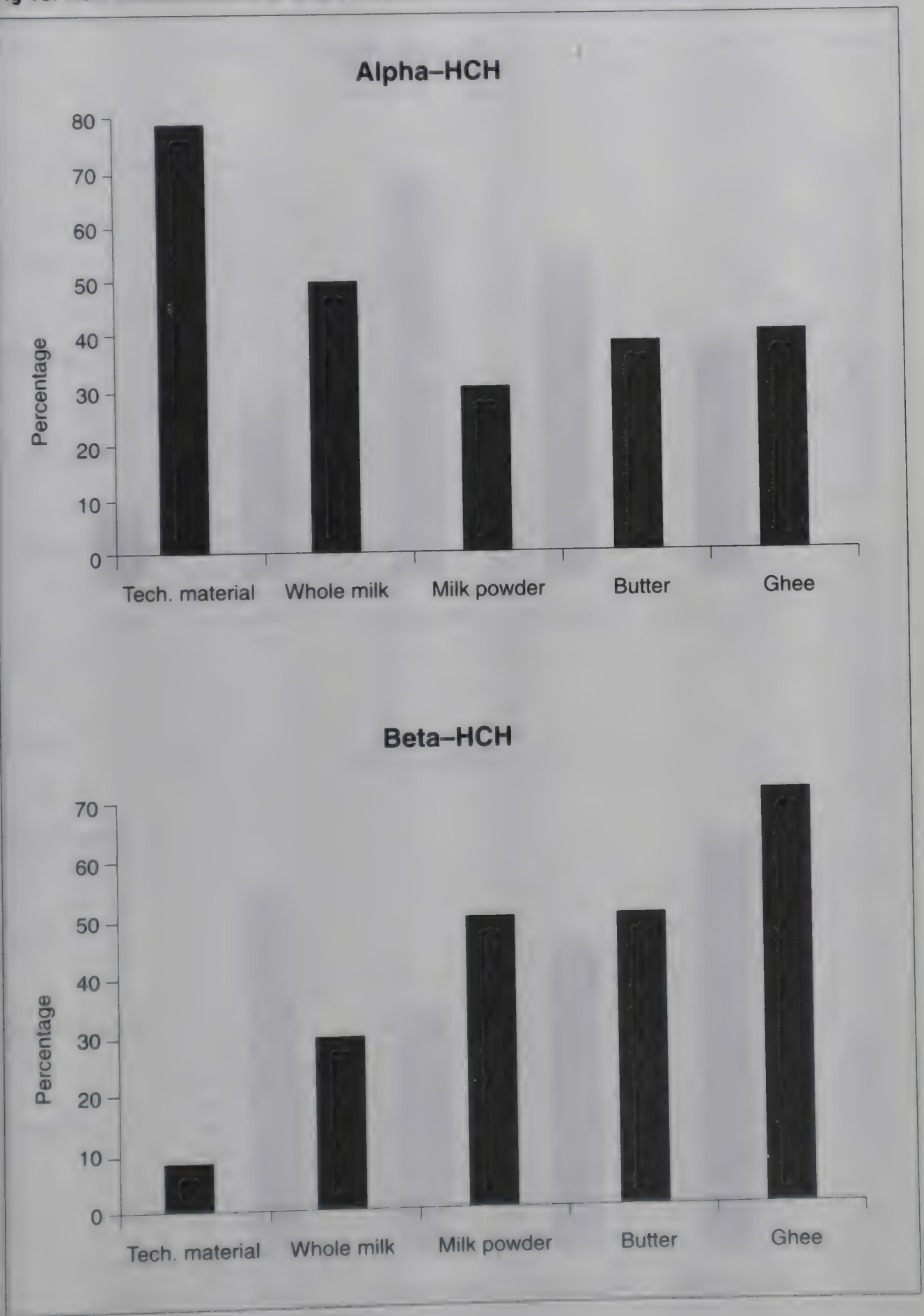


Fig 10: contd.

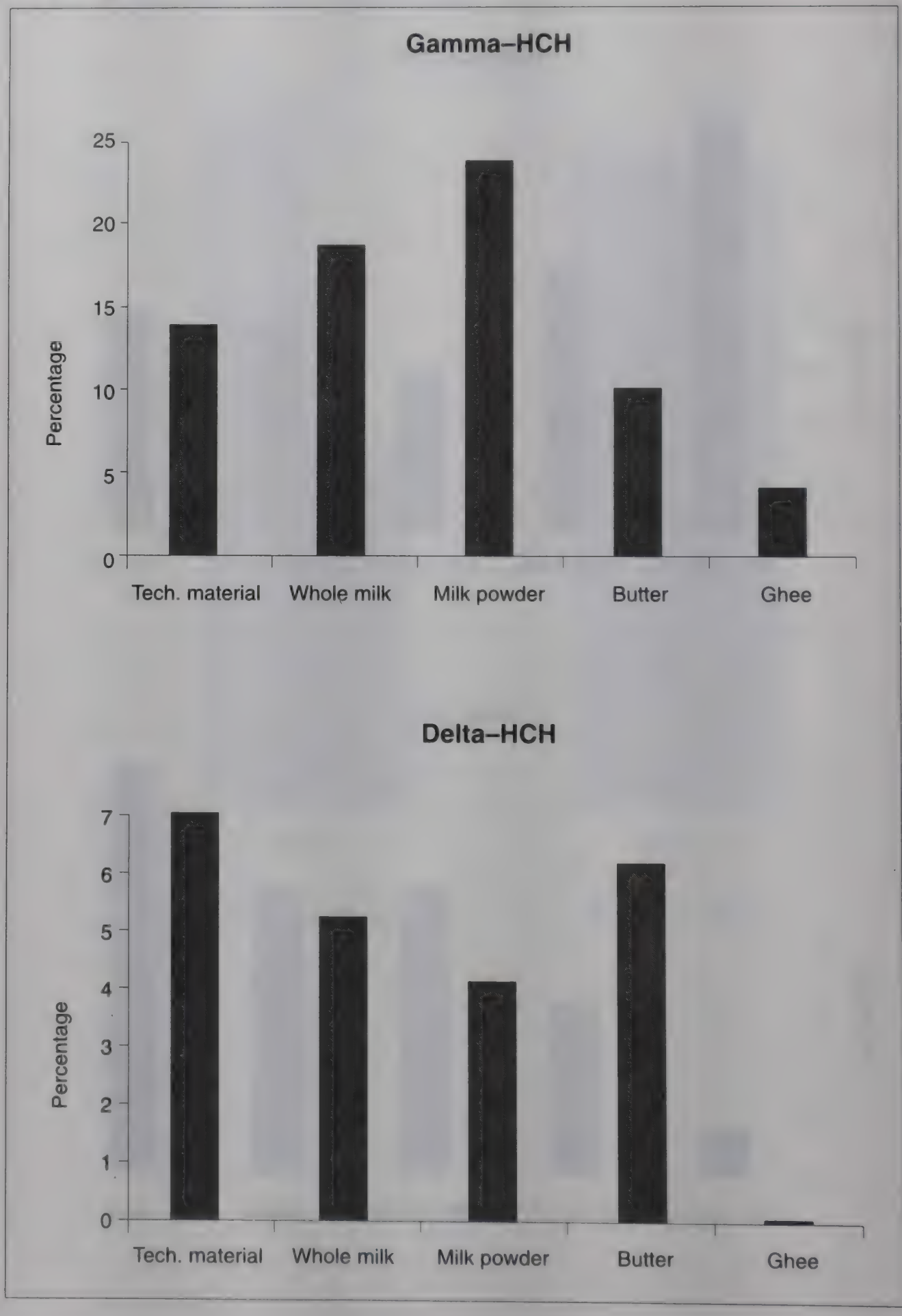

Gamma–HCH
Percentage
25
20
15
10
5
0
Tech. material
Whole milk
Milk powder
Butter
Ghee
Delta–HCH
Percentage
7
6
5
4
3
2
1
0
Tech. material
Whole milk
Milk powder
Butter
Ghee

Table 19. HCH Contamination of Bovine Milk from 12 States of India

State	Pesticide	No. of samples analyzed	No. of samples above DL	No. of sample above TL (PFA)	No. of samples s above MRL (FRG)/ codex	Mean
Himachal Pradesh	alpha–HCH	120	105	8	92	0.014
	beta–HCH	120	110	21	103	0.014
	Gamma–HCH	120	37	1	1	0.003
	delta–HCH	120	83	2	–	0.006
Punjab	alpha–HCH	263	232	16	223	0.021
	beta–HCH	263	236	145	228	0.032
	Gamma–HCH	263	109	47	47	0.007
	delta–HCH	263	115	17	–	0.007
Haryana	alpha–HCH	120	91	7	86	0.013
	beta–HCH	120	114	58	111	0.030
	Gamma–HCH	120	18	7	7	0.003
	delta–HCH	120	37	5	–	0.005
Uttar Pradesh	alpha–HCH	240	217	124	215	0.115
	beta–HCH	240	213	143	213	0.092
	Gamma–HCH	240	163	101	101	0.027
	delta–HCH	240	–	–	–	–
Madhya Pradesh	alpha–HCH	240	205	26	185	0.020
	beta–HCH	240	233	109	228	0.028
	Gamma–HCH	240	74	10	10	0.003
	delta–HCH	240	127	7	–	0.005
Maharashtra	alpha–HCH	299	298	1	298	0.020
	beta–HCH	299	288	35	288	0.015
	Gamma–HCH	299	240	70	70	0.009
	delta–HCH	299	154	1	–	0.005
Gujarat	alpha–HCH	120	120	14	120	0.030
	beta–HCH	120	117	46	117	0.021
	Gamma–HCH	120	102	61	61	0.014
	delta–HCH	120	83	3	–	0.008
West Bengal	alpha–HCH	120	76	27	76	0.111
	beta–HCH	120	52	31	52	0.042
	Gamma–HCH	120	29	23	23	0.017
	delta–HCH	–	–	–	–	–
Bihar	alpha–HCH	120	108	45	101	0.075
	beta–HCH	120	115	89	114	0.079
	Gamma–HCH	120	71	29	29	0.009
	delta–HCH	120	104	24	–	0.016
Andhra Pradesh	alpha–HCH	240	188	125	187	0.172
	beta–HCH	240	166	149	164	0.298
	Gamma–HCH	240	164	138	138	0.088
	delta–HCH	240	60	17	–	0.005
Karnataka	alpha–HCH	203	158	52	150	0.113
	beta–HCH	203	111	49	102	0.064
	Gamma–HCH	203	100	60	60	0.002
	delta– HCH	203	–	–	–	–
Kerala	alpha–HCH	120	119	19	119	0.033
	beta–HCH	120	119	58	119	0.027
	Gamma–HCH	120	113	61	61	0.015
	delta–HCH	120	77	–	–	0.007

Source: *Surveillance of food contaminants in India, Report of the ICMR task force study. ICMR. 1993.*

Table 20. DDT Contamination of Bovine Milk from 12 States of India

State	Pesticide	No. of samples analyzed	No. of samples above DL	No. of sample above TL (PFA)	No. of samples s above MRL (FRG)/ codex	Mean
Himachal Pradesh	Total DDT	120	120	67	67	0.091
Punjab	Total DDT	263	257	133	133	0.111
Haryana	Total DDT	120	116	6	6	0.022
Uttar Pradesh	Total DDT	240	137	26	26	0.030
Madhya Pradesh	Total DDT	240	230	52	52	0.042
Maharashtra	Total DDT	299	299	222	222	0.080
Gujarat	Total DDT	120	120	84	84	0.091
West Bengal	Total DDT	120	43	15	15	0.021
Bihar	Total DDT	120	115	23	–	0.041
Andhra Pradesh	Total DDT	240	208	137	–	0.207
Karnataka	Total DDT	203	45	36	36	0.047
Kerala	Total DDT	120	115	11	11	0.030

Source: *Surveillance of food contaminants in India. Report of ICMR task force study (Part I). 1993. Indian Council of Medical Research, New Delhi.*

Table 21. Maximum Residue Limit (MRL) Values of Pesticides in Food Commodities

Name of pesticide	Food	MRL (mg/kg)
Acephate	Safflower seed	2.0
	Cottonseed	2.0
Alachlor	Cottonseed	0.05
	Groundnut	0.05
	Maize	0.10
	Soybean	0.10
Aldicarb	Potato	0.5
	Chewing tobacco	0.1
Aldrin, dieldrin	Foodgrains	0.01
	Milk & milk products	0.15
	Fruits & vegetables	0.1
	Meat	0.2
	Eggs	0.1
Alpha nephthyl acetic acid (ANA)	Pineapple	0.50
Atrazine	Maize	Nil
	Sugarcane	0.25
Benomyl	Foodgrains	0.5
	Milled foodgrains	0.12
	Vegetables	0.50
	Mango	2.0
	Banana (whole)	1.0
	Other fruits	5.0
	Cottonseed	0.10
	Groundnut	0.10
	Sugar beet	0.10
	Dried fruits	0.10
	Eggs	0.10
	Meat & poultry	0.10
	Milk & milk products	0.10
Bitertanol	Wheat	0.05
	Groundnut	0.10
Captafol	Tomato	5.00
Captan	Fruits & vegetables	15.00
Carbaryl	Foodgrains	0.5
	Okra and leafy vegetables	10.0
	Potatoes	0.2
	Cottonseed (whole)	1.0
	Maize cob	1.0
Carbendazim	Foodgrains	0.5
	Milled foodgrains	0.12
	Vegetables	0.50
	Mango	2.0
	Banana (whole)	1.0
	Other fruits	5.0
	Cottonseed	0.10
	Groundnut	0.10
	Sugar beet	0.10
	Dried fruits	0.10
	Eggs	0.1
	Meat & poultry	0.1
	Milk & milk products	0.1

contd...

contd...

Name of pesticide	Food	MRL (mg/kg)
Carbofuran	Foodgrains	0.10
	Milled foodgrains	0.03
	Fruits & vegetables	0.10
	Oilseed	0.10
	Sugarcane	0.10
	Meat & poultry	0.10
	Milk & milk products	0.05
Cartaphydrochloride	Rice	0.50
Chlordane	Foodgrains	0.05
	Milk & milk products	0.05
	Vegetables	0.2
	Fruits	0.1
	Sugar beet	0.3
Chlorfenvinphos	Foodgrains	0.025
	Milled foodgrains	0.006
	Milk & milk products	0.2
	Meat & poultry	0.2
	Vegetables	0.05
	Groundnut	0.005
	Cottonseed	0.05
Chlormequatchloride	Grapes	1.00
	Cottonseed	1.00
Chlorobenzilate	Fruits	1.0
	Dried fruits, almonds & walnuts	0.2
Chlorothalonil	Groundnut	0.10
	Potato	0.10
Chlorpyriphos	Foodgrains	0.05
	Milled foodgrains	0.01
	Fruits	0.5
	Potatoes & onions	0.01
	Cauliflower & cabbage	0.01
	Other vegetables	0.2
	Meat & poultry	0.1
	Milk & milk products	0.01
	Cottonseed	0.05
	Cottonseed oil (crude)	0.025
Copper oxychloride	Fruits	20.00
	Potatoes	1.00
	Other vegetables	20.00
Cypermethrin	Wheat grains	0.05
	Milled wheat grains	0.01
	Brinjal	0.20
	Cabbage	2.00
	Okra	0.20
	Oilseeds (except groundnut)	0.20
	Meat & poultry	0.20
	Milk & milk products	0.01
2,4–D	Foodgrains	0.01
	Milled foodgrains	0.03
	Potatoes	0.2
	Milk & milk products	0.5
	Meat & poultry	0.05
	Eggs	0.05
	Fruits	2.0

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Name of pesticide	Food	MRL (mg/kg)
DDT	Milk & milk products	1.25
	Fruits & vegetables	3.5
	Meat, poultry & fish	7.0
	Eggs	0.5
Decamethrin / deltamethrin	Cottonseed	0.1
	Fruits with edible peel	0.1
	Bananas	0.05
	Brassica, and other leafy vegetables	0.05
	Bulb vegetables	0.1
	Cereal grains	2.0
	Grapes	0.05
	Leafy vegetables	0.2
	Oilseeds	0.1
	Sweet oranges	0.05
	Root & tuber vegetables	0.01
Diazinon	Soybean	0.05
	Cauliflower	0.5
Dichlorvos	Foodgrains	1.0
	Milled foodgrains	0.25
	Vegetables	0.15
	Fruits	0.1
	Fruits & vegetables	5.0
	Tea	5.0
Diflubenzuron	Cottonseed	0.20
Dimethoate	Fruits & vegetables	2.0
Dithiocarbamates	Foodgrains	0.2
	Milled foodgrains	0.05
	Potatoes	0.1
	Tomatoes	3.0
	Cherries	1.0
	Other fruits	3.0
Diuron	Cottonseed	1.00
	Banana	0.10
	Maize	0.50
	Citrus (sweet orange)	1.00
	Grapes	1.00
Dodine	Apple	5.00
Edifenphos	Rice	0.02
	Rice bran	1.0
	Eggs	0.01
	Meat & poultry	0.02
	Milk & milk products	0.01
Endosulfan	Fruits & vegetables	2.0
	Cottonseed	0.5
	Cottonseed oil	0.2
Ethephon	Pineapple	2.00
	Coffee	0.10
	Tomato	2.00
	Mango	2.00
Ethion	Tea	5.0
	Cucumber & squash	0.5
	Other vegetables	1.0
	Cottonseed	0.5
	Milk & milk products	0.5

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Name of pesticide	Food	MRL (mg/kg)
	Meat & poultry	0.2
	Eggs	0.2
	Foodgrains	0.025
	Milled foodgrains	0.006
	Peaches	1.0
	Other fruits	2.0
	Dried fruits	0.1
Fenitrothion	Foodgrains	0.02
	Milled foodgrains	0.005
	Milk & milk products	0.05
	Fuits	0.5
	Vegetables	0.3
	Meat	0.03
Fenthion	Foodgrains	0.10
	Milled foodgrains	0.03
	Onion	0.1
	Potatoes	0.05
	Beans	0.10
	Peas	0.50
	Tomatoes	0.50
	Other vegetables	1.0
	Musk melon	2.0
	Meat & poultry	2.00
	Milk & milk products	0.05
Fenvalerate	Cauliflower	2.00
	Brinjal	2.00
	Okra	2.00
	Cottonseed	0.20
	Cottonseed oil	0.10
	Meat & poultry	1.00
	Milk & milk products	0.01
Fluchloralin	Cottonseed	0.05
	Soybean	0.05
Formothion	Citrus fruits	0.2
	Other fruits	1.0
	Vegetables	2.0
	Pepper & tomatoes	1.0
Heptachlor	Foodgrains	0.01
	Milled foodgrains	0.002
	Milk & products	0.15
	Vegetables	0.055
Hexachlorocyclohexane (HCH)		
(a) Alpha–isomer	Rice grains (unpolished)	0.10
	Rice grains (polished)	0.05
	Milk (whole)	0.05
(b) Beta –isomer	Rice grains (unpolished)	0.10
	Rice grain (polished)	0.5
	Milk (whole)	0.02
(c) Gamma–isomer	Foodgrains (except rice)	0.10
	Milled foodgrains	Nil
	Rice grain (unpolished)	0.10
	Rice grains (polished)	0.05
	Milk (whole)	0.01
	Milk products	0.20
	Fruits & vegetables	3.00
	Eggs (shell free)	0.10
	Meat and poultry	2.00

contd...

contd...

Name of pesticide	Food	MRL (mg/kg)
(d) Delta–isomer	Rice grains (unpolished)	0.10
	Rice grains (polished)	0.05
	Milk (whole)	0.02
Hydrogen cyanide	Foodgrains	37.5
	Milled foodgrains	3.0
Hydrogen phosphide	Foodgrains	0.1
	Milled foodgrains	25.0
Inorganic bromide	Foodgrains	25.0
	Milled foodgrains	25.0
	Fruits	30.0
	Dried fruits & spices	100.0
Lindane	Foodgrains	2.25
	Milk & milk products	0.2
	Fruits & vegetables	3.0
	Eggs	0.1
	Meat & poultry	2.0
Malathion	Foodgrains	4.0
	Milled foodgrains	1.0
	Fruits	4.0
	Vegetables	3.0
	Dried fruits	8.0
Malic hydrazide	Onions	15.00
	Potatoes	50.00
Metalaxyl	Bajra	0.05
	Maize	0.05
	Sorghum	0.05
Methamidophos	Safflower seed	0.1
	Cottonseed	0.1
	Sugarcane	0.25
Methomyl	Cotton seed	0.10
Methyl chloro-phenoxyacetic acid (MCPA)	Rice	0.05
	Wheat	0.05
Monocrotophos	Foodgrains	0.025
	Milled foodgrains	0.006
	Citrus fruits	0.2
	Other fruits	1.0
	Carrot, turnip, potatoes & sugar beet	0.05
	Onion & peas	0.1
	Other vegetables	0.2
	Cottonseed	0.1
	Cottonseed oil (raw)	0.05
	Meat & poultry	0.02
	Eggs	0.02
	Coffee (Raw beans)	0.1
Oxadiazon	Rice	0.03
Oxydemeton methyl	Foodgrains	0.02
Paraquat	Foodgrains	0.1
	Milled foodgrains	0.025
	Potatoes	0.2
	Other vegetables	0.05
	Cottonseed	0.2
	Cottonseed oil	0.05
	Milk (whole)	0.01
	Fruits	0.05

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Name of pesticide	Food	MRL (mg/kg)
Parathion	Fruits & vegetables	0.5
Parathion (methyl)	Fruits	0.2
	Vegetables	1.0
Permethrin	Cucumber	0.50
	Cottonseed	0.50
	Soybean	0.05
	Sunflower seed	1.00
Phenthioate	Foodgrains	0.05
	Milled foodgrains	0.01
	Oilseeds	0.03
	Edible oils	0.01
	Eggs	0.05
	Meat & poultry	0.05
	Milk & milk products	0.01
Phorate	Foodgrains	0.05
	Milled foodgrains	0.01
	Tomatoes	0.10
	Other vegetables	0.05
	Fruits	0.05
	Oilseeds	0.05
	Edible oils	0.03
	Sugarcane	0.05
	Eggs	0.05
	Meat & poultry	0.05
	Milk & milk products	0.05
Phosalone	Pears	2.0
	Citrus fruits	1.0
	Other fruits	5.0
	Potatoes	0.1
	Other vegetables	1.0
	Rapeseed / Mustard oil	0.05
Phosphamidon	Foodgrains	0.05
	Fruits & vegetables	0.2
Primiphos–methyl	Rice	0.50
	Wheat grains	5.00
	Milled wheat grains	1.25
	Eggs	0.05
	Meat & poultry	0.05
	Milk & milk products	0.05
Pyrethrins	Foodgrains	1.5
	Milled foodgrains	0.5
	Fruits & vegetables	1.0
Quinalphos	Rice	0.01
	Pigeonpea	0.01
	Cardamom	0.01
	Tea	0.01
	Fish	0.01
Simazine	Maize	Nil
	Sugarcane	0.25
Thiometon	Foodgrains	0.025
	Milled foodgrains	0.006
	Fruits	0.5
	Potatoes, carrots & sugar beet	0.05
	Other vegetables	0.5

contd...

Table 21. contd...

Name of pesticide	Food	MRL (mg/kg)
Thiophanatemethyl	Apple	5.00
	Papaya	7.00
Trichlorfon	Food grains	0.05
	Milled foodgrains	0.0125
	Sugar beet	0.05
	Fruits & vegetables	0.1
	Oil seeds	0.1
	Edible oil (refined)	0.05
	Meat & poultry	0.1
	Milled foodgrains	0.006
	Fruits	0.5
	Potatoes, carrots & sugar beet	0.05
	Other vegetables	0.5

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012, page 132.*

Table 22. Permissible Limits for Pesticide Contamination in Drinking Water

Pesticides	Standards (mg/L)
Alachlor	0.002
Aldicarb[2]	0.003
Aldicarb sulphone[2]	0.003
Aldicarb sulphoxide[2]	0.004
Atrazine	0.003
Carbofuran	0.04
Chlordane	0.002
2,4–D	0.1
Dalapon	0.2
DBCP(1,2,Dibromo–3–chloropropane)	0.0002
Dinoseb	0.007
Diqauat	0.02
EDB (Ethylene dibromide)	0.00005
Endothall	0.1
Endrin	0.0002
Glyphosate	0.7
Heptachlor	0.0004
Heptachlor epoxide	0.0002
Lindane	0.004
Methoxychlor	0.1
Oxamyl (Vydate)	0.2
Pentachlorophenol	0.001
Picloram	0.5
Simazine	0.004
Toxaphene	0.005
2,4,5–TP (Silver)	0.01

Source: *Environmental Handbook 1991, TVA, (Updated 1992)*

The Health Effects of Pesticides

Pesticides have become a potential health hazard to the manufacturer, consumer and the environment. Air, water and food have become contaminated with pesticides as a result of their extensive misuse. The risks to humans may be short-term or long-term, depending on the exposure period to these chemicals. The main groups of pesticides of concern are insecticides, herbicides, fungicides and a few soil fumigants. Agent Orange, a herbicide which is a mixture of 2,4–D and 2,4,5–T, was used extensively as a defoliant in the Vietnam war in the late sixties. People who at that time were residing around the sprayed area, and their children, still suffer from the adverse health effects. Mothers either have stillbirths or give birth to spastics or babies without limbs.

In India, 147 pesticides have been registered for use at present and the tolerance limits of only 50 have been evaluated. Therefore, we are not only at risk from pesticides which are being commonly used and whose tolerance limits are known, but also from a wide spectrum of pesticides which have entered the market and our food commodities without even the maximum permissible limit being known.

In the present scenario, a multidisciplinary integrated approach involving toxicology, epidemiology, physiology and behavioural sciences is essential for the proper assessment of human health hazards related to pesticide exposure.

Major Reported Cases of Pesticide Poisoning

Poisoning due to pesticides can be occupational (workers involved in the manufacturing process, sprayers or farmers), accidental or intentional (suicide cases). Even through the daily diet the general population is exposed to small quantities of various types of pesticides. In 1958, Kerala had the first reported case of pesticide poisoning where 100 people died due to parathion poisoning. Pesticide poisoning cases have been reported from Bengal, Karnataka, Andhra Pradesh, Bihar, Tamil Nadu, Punjab, Haryana, Himachal Pradesh, Maharashtra, Uttar Pradesh, West Bengal and Gujarat. The data presented in the map does not give a complete picture because there are many poisoning cases which go unreported. Lack of systematic and authentic data on poisoning is a serious hurdle in assessing pesticide poisoning.

Sources:

- *Pesticides, Development, Toxicity and Safety*. R.B. Raizada and T.S.S. Diksith (eds.), Industrial Toxicology Research Centre, Lucknow, India, 1992.
- Laha N.N., A. Shankar and R. Chopra, 1988. Journal Ass. Phys. India. 36: 594.
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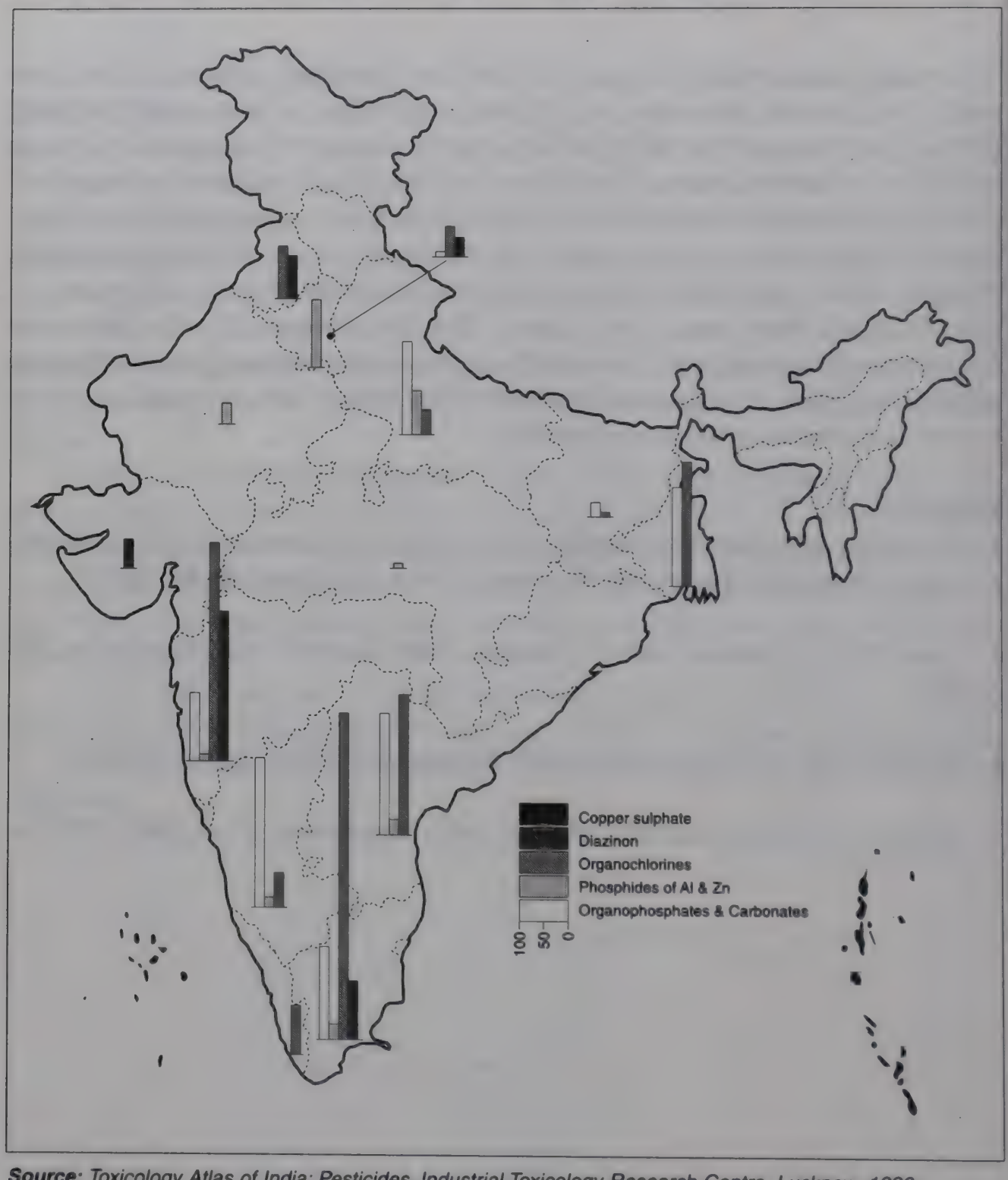
- Dagli A.J., J.S. Moos and W.A. Shaikh, 1981. Journal Ass. Phys. India. 29: 794.

Map 5: Major Reported Cases of Pesticide Poisoning in India



Source: *Toxicology Atlas of India: Pesticides. Industrial Toxicology Research Centre, Lucknow, 1990.*

Chlorinated Hydrocarbon Pesticide Residues in Human Milk

Monitoring of breast milk is restricted only to a few northern states. Chlorinated hydrocarbons which are present in fat get dislodged and are secreted through breast milk. Infants are thus exposed to high concentrations of pesticides through breast milk. In order to understand the load of chlorinated hydrocarbon pesticides like DDT and HCH in mothers and their infants, there is a need to carry out extensive monitoring studies in different parts of the country, so as to ascertain exposures of these hazardous chemical compounds.

Sources:

- Nair A., R. Mandapati, P. Dureja and M.K.K. Pillai, 1996. Bulletin of Environmental Contamination and Toxicology. 56:58–64.
- Kumar S., A. Kaushik and C.P. Kaushik, 1996. Toxicology and Environmental Chemistry. 55:127–133.
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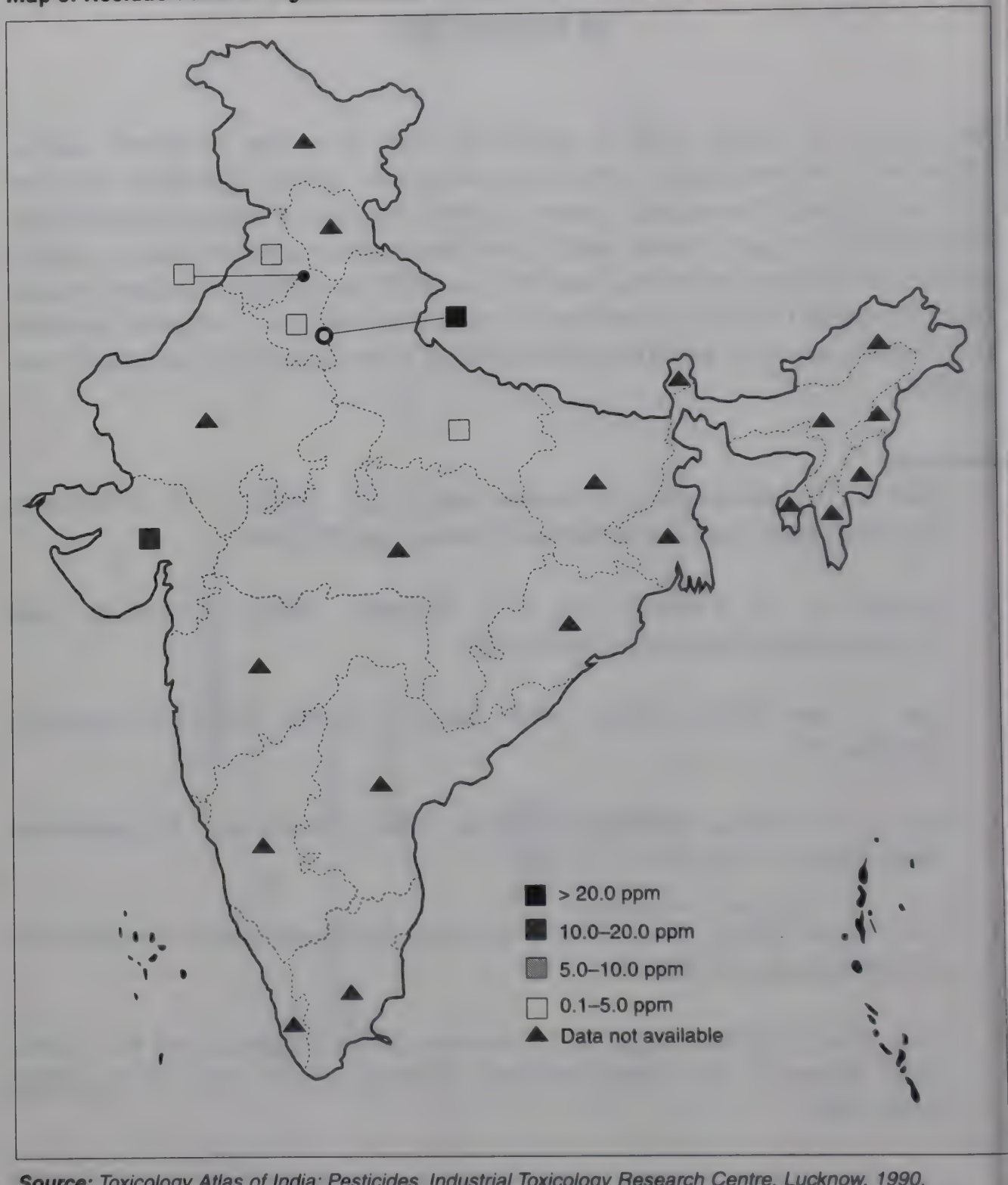
Map 6: Residue Level of Organochlorine Pesticides in Human Milk (maximum levels reported)



Source: *Toxicology Atlas of India: Pesticides. Industrial Toxicology Research Centre, Lucknow, 1990.*

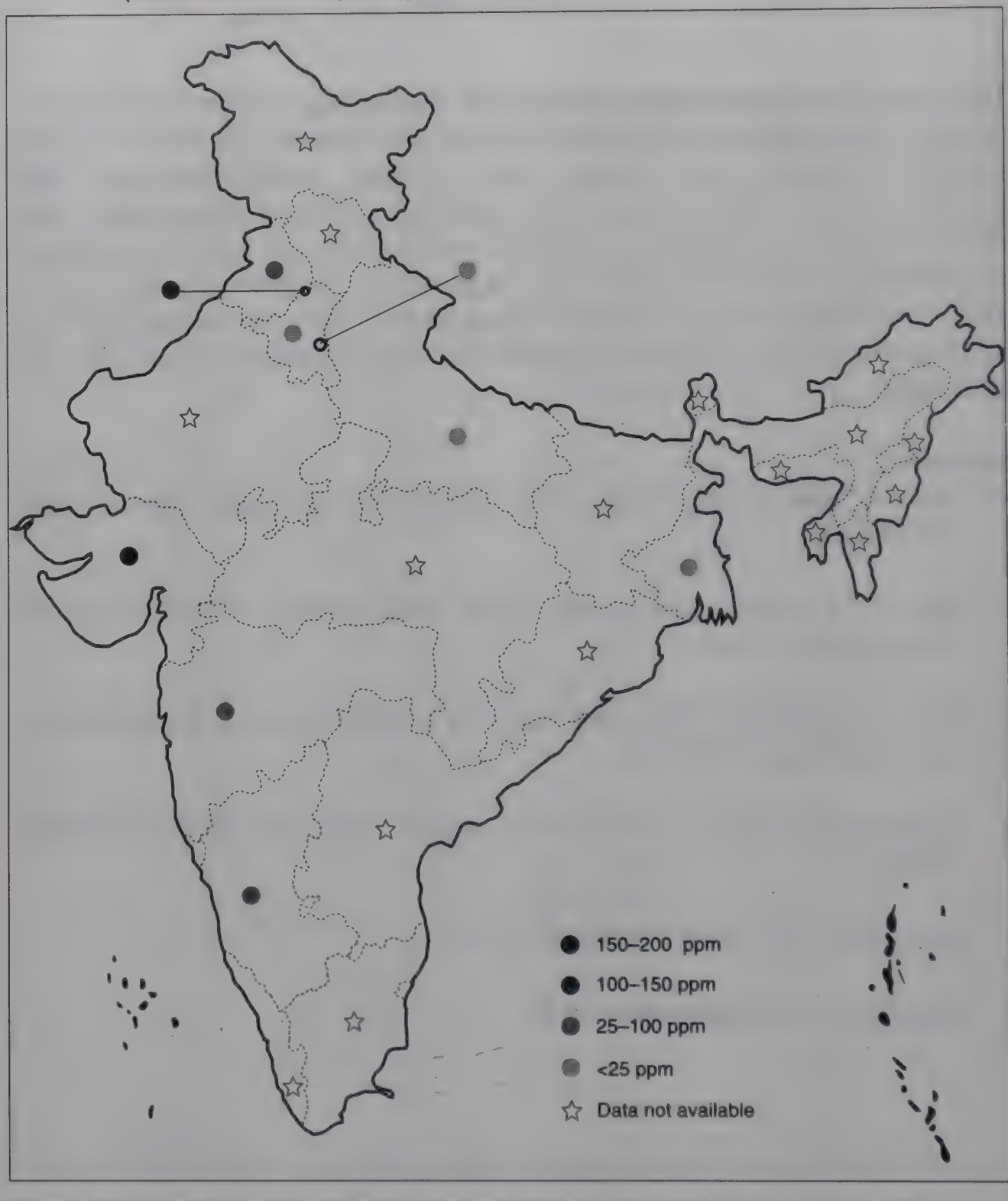
Chlorinated Hydrocarbon Pesticide Residues in Human Fat

The data on pesticide content in human fat is available only from a few states in India. The samples from Gujarat showed the highest concentration compared to Haryana, Delhi, Punjab, Uttar Pradesh, Maharashtra and West Bengal. We know that the vegetables from the states of Tamil Nadu, Uttar Pradesh, Kerala and Madhya Pradesh showed 90 to 100 per cent pesticide contamination and that people are exposed to pesticides through food. There is an urgent need to analyze human fat from different states of India so as to ascertain the pesticide exposure and take appropriate measures for food safety.

Sources:

- Nair A. and M.K.K. Pillai, 1992. Science of the Total Environment. 121:145–157.
- Nair A., P. Dureja and M.K.K. Pillai, 1992. Human and Experimental Toxicology. 11: 43–45.
- Nair A. and M.K.K. Pillai, 1989. Bulletin of Environmental Contamination and Toxicology. 42:682–86.
- Kaphalia B.S. and T.D. Seth, 1983. Indian Journal of Medical Science. 77:245.
- Gupta S.K. et al., 1984. Pesticides, 18:14.
- Gupta S.K. et al., Pesticides, 16:11.

Map 7: Residue Level of Organochlorine Pesticides in Human Adipose Tissue (maximum levels reported)



Source: *Toxicology Atlas of India: Pesticides. Industrial Toxicology Research Centre, Lucknow, 1990.*

Chlorinated Hydrocarbon Pesticide Residues in Human Blood

The information on chlorinated hydrocarbon pesticides like DDT, HCH, aldrin, dieldrin and HCB in blood is sparse in India. Data on pesticide levels in human blood are available in very few states. These are Maharashtra, Uttar Pradesh, Gujarat and Delhi.

Sources:

- Nair A., R. Mandapati, P. Dureja and M.K.K. Pillai, 1996. Bulletin of Environmental Contamination and Toxicology. 56:58–64.
- Nair A. and M.K.K. Pillai, 1992. Science of the Total Environment. 121:145–157.
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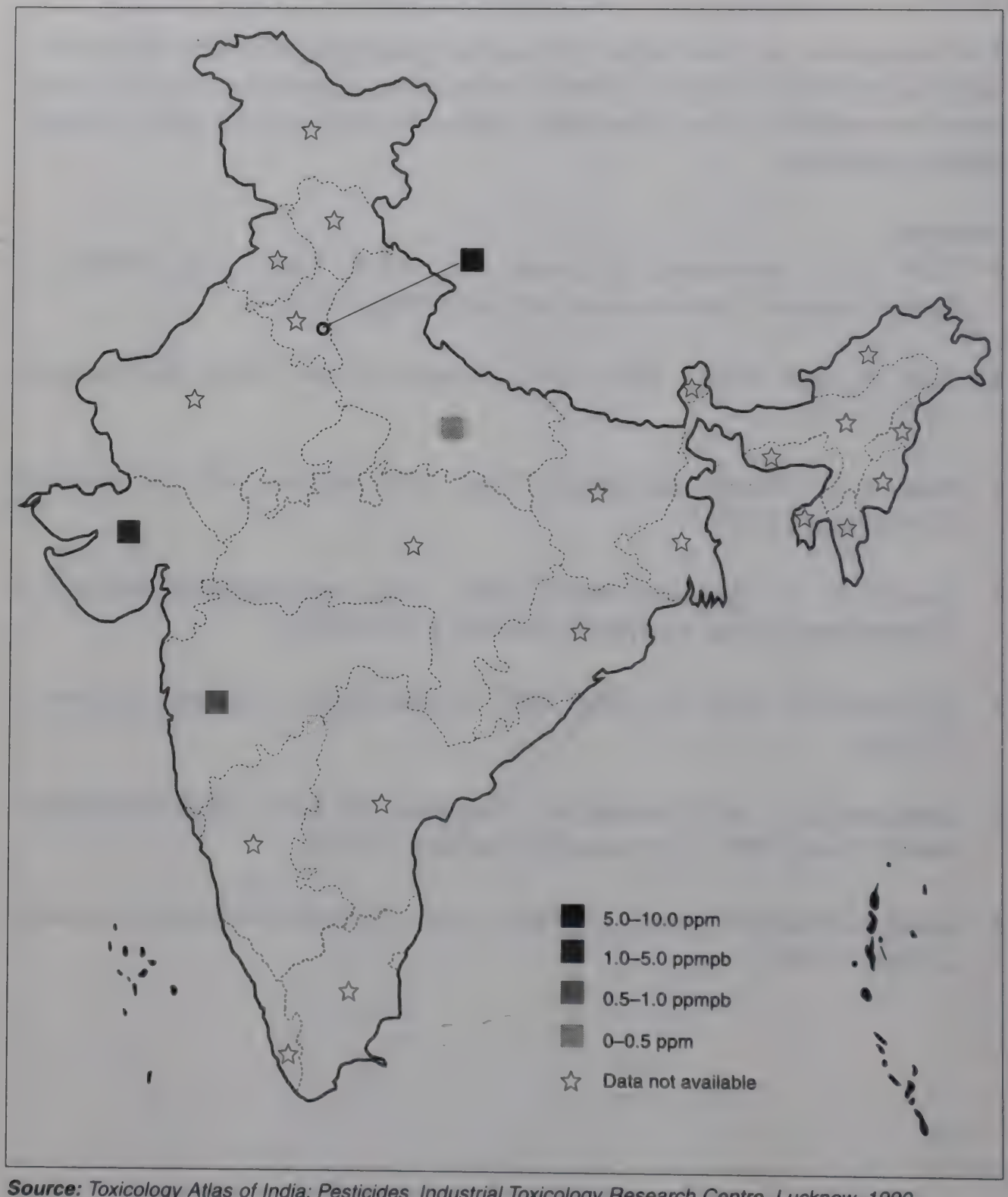
- Balasubramanian S. and G.S. Rajulu, 1978. National Academy of Science Letters. I:429.

Map 8: Residue Level of Organochlorine Pesticides in Human Blood (maximum levels reported)



Source: *Toxicology Atlas of India: Pesticides. Industrial Toxicology Research Centre, Lucknow, 1990.*

Table 23. Hazard Classification of Pesticides

Hazard Level	Oral LD_{50} for rat mg/kg body weight	ADI mg/kg body weight
Extremely hazardous e.g., *Aldicarb, Monocrotophos, Parathion, Phosphamidon*	5 or less	0.0001 or less
Highly hazardous e.g., *Carbofuran, Daizinon, Dimethoate*	5–50	0.001–0.01
Moderately hazardous e.g., *Carbaryl, 2,4–D, DDT, HCH, Lindane, Malathion, Ziram*	50–500	0.01–0.1
Slightly hazardous e.g., *Carbendazim, Captan*	500–5000	0.1–1.0

Source: *Toxicology Atlas Map of India: Pesticides. 1990 Industrial Toxicology Research Centre, Lucknow.*

Table 24. Acute Pesticide Poisoning and Mortality Reported from Different Countries

Country	Year	Nature of Pesticide Exposure	No. of Cases	No. of Deaths	Pesticides Involved
Sri Lanka*	1975–80	1,2,3	13,000	1,000	Mainly OP pesticides
Sri Lanka*	1988	1,2,3	50,000	2,000	Mainly OP pesticides
Philippines	1980–87	1,2,3	4,031	603	Mainly OP pesticides
Pakistan	1976	1,2,3	2,800	5	Iso–málathion
Thailand	1987	1,2,3	4,633	5	Parathion
Malaysia	1978–86	1,2,3	569	310	Paraquat
Kenya**	1981	1,2,3	721	13	OP pesticides
Colombia	1984	1	600	88	Parathion & paraquat
Brazil	1984	1	173	nil	OP pesticides
China	1983–88	1	573	5	Synthetic pyrethroids
Qatar	1967	2a	691	24	Endrin
India	1958	2a	360	102	Parathion
Mexico	1968	2a	559	16	Parathion
Turkey	1955–59	2a	3,000–5,000	3 to 11% of total cases	Hexachlorobenzene
U.S.A.	1985	2a	1,175	nil	Aldicarb

Note: **Annual average, ** Record from Kenyatta National Hospital*
1 – occupational, 2– accidental, 2a– accidental food consumption, 3– intentional.

Source: *Pillai M K K. and Amit Nair ,1995. Pesticide contaminants and human health. In: Environmental Contaminants, Ecosystem and Human Health. Eds S.K. Majumdar, E.W. Miller and F.J. Brenner The Pennsylvania Academy of Science, pp. 216–235*

Table 25. Diseases Associated with the Use of Pesticides

Suspected Pesticides	Diseases/Effects	Whether used in India: Yes/No
DDT	Chronic liver damage — cirrhosis and chronic hepatitis, endocrine & reproductive disorders, immuno–suppression, cytogenic effects, breast cancer, Non–Hodgkin's Lymphoma, polyneuritis.	Yes, banned in agriculture
HCH	Chronic liver damage — cirrhosis and chronic hepatitis, endocrine & reproductive disorders, allergic dermatitis, breast cancer, Non–Hodgkin's Lymphoma.	Yes, banned in 1998
Carbaryl	Within the stomach produces N–nitrocarbaryl which is a well–known carcinogen, Non–Hodgkin's Lymphoma, brain cancer.	Yes
2,4–D (Herbicide)	Twofold excess of all cancers in Swedish railway workers, Non–Hodgkin's Lymphoma.	Yes
2,4,5–T (Agent Orange)	Soft tissue sarcoma, reproductive disorders.	No
MCPA	Soft tissue sarcoma, prostate cancer.	No
Triazines	Cancer of testes	No
ANTU	Urinary bladder cancer	Yes
Paraquat	Parkinson's & Alzheimer's diseases.	Yes
Chlordane	Brain cancer, Non–Hodgkin's Lymphoma, reproductive disorders, blood dyscariasis.	No
DBCP	Reproductive disorders.	No
Heptachlor	Reproductive disorders, blood dyscariasis.	No
Lindane	Non–Hodgkin's Lymphoma, brain cancer, lung cancer.	Yes
Aldrin	Lung cancer, liver diseases.	Anti–termite only
Dieldrin	Liver diseases, Parkinson's & Alzheimer's diseases.	No
Diazinon	Non–Hodgkin's Lymphoma.	Yes
Malathion	Non–Hodgkin's Lymphoma.	Yes
Nicotine	Non–Hodgkin's Lymphoma.	Yes
Ziram	Dermal sensitivity reactions, itching, erythema, burning sensation.	Yes
Phosphine	Cytogenic effects	No
Pentachlorophenol	Aplastic anemias.	No

Source: *Pillai M.K.K. and Amit Nair, 1995. Pesticide contaminants and human health. In: Environmental Contaminants, Ecosystem and Human Health. Eds S.K. Majumdar, E.W. Miller and F.J. Brenner. The Pennsylvania Academy of Science; pp. 216–235*

Table 26. Health Effects of Pesticide Poisoning

Pesticide	Health Effects
Organochlorines	
Aldrin, chlordane, heptachlor, DDT, HCH, lindane, dicofol, endosulphan	Nervousness, headache, dizziness; nausea, vomiting, tremors and diarrhoea.
Carbamates	
Carbaryl, aldicarb, thiobencarb, propoxur	Giddiness, headache, nausea, diarrhoea , blurred vision, muscular twitching, convulsions.
Organophosphates	
Malathion, methyl parathion, acephate, monocrotophos, oxydemeton, phorate phosalone, quinalphos temephos, DDVP, phosphamidon	Same as carbamates.
Synthetic pyrethroids	
Cyhalothrin, cypermethrin, deltamethrin, fenvalerate, fluvalinate, fenpropathrin	Irritation of oral/ nasal mucosae, salivation, convulsive seizures, facial sensations.
Mercury compounds	
PMA, MEMC	Tingling of fingers, fingers–tips, tongue may occur, headache, loss of peripheral vision. Contact with skin may cause blisters or dermatitis.
Fumigants	
Ethylene bromide, methyl bromide, ethylene dibromide carbon tetrachloride mixture	Respiratory irritation and damage to lungs, itching, dermatitis, blistering of skin and corneal ulceration, dizziness, convulsions and respiratory failure.
Dinitrocompounds	
DNOC, PCP, Binapacryl, dinitrophenol dinoseb	Yellow staining of skin, tremors, increased respiratory rate, sweating, nausea, restlessness and rapid heart beat.
Copper compounds	
Copper oxychloride copper sulphate	Gastrointestinal and renal manifestations.
Anticoagulants – Rodenticides	
Brodifacoum, warfarin, bromadiolone, coumochlor, chlorophocinone	Nausea, vomitting, diarrhoea, bleeding from nose, gums and coma.
Bipyridyniums	
Diquat, paraquat	Irritation of mouth and throat with nausea, diarrhoea, abdominal pain.
Zinc phoshide and aluminium phosphide	Vomiting, cough, liver and kidney failure
Nicotine	Neurological manifestations.
Arsenic compounds	Severe gastrointestinal problems.

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012, page 128.*

Table 27. Clinical Symptoms of Acute Poisoning with OP Pesticides

Target Site	Clinical Manifestation
Muscarinic synapses	Respiratory problems, increased bronchial secretion, dyspnea,lung edema, hypotension, bradycardia, heart spasms, vomiting, abdominal pain, cramps, increased salivation, gastrointestinal hyermotility, diarrhoea, miosis of pupils, blurred vision, increased lacrimation, excessive perspiration, involuntary defecation and urination.
Nicotinic synapses	Voluntary muscles – cramps, muscular twitches, fasciculations and paralysis, tachycardia, hypertension.
Central nervous system	Restlessness, irritability, anxiety, confusion, dizziness, tension, insomnia, ataxia, coma, convulsions, respiratory depression, cardiac block and arrest.

Source: *Pillai M.K.K. and Amit Nair, 1995. Pesticide contaminants and human health. In: Environmental Contaminants, Ecosystem and Human Health, Eds S.K. Majumdar, E.W. Miller and F.J. Brenner. The Pennsylvania Academy of Science, pp. 216–235.*

Table 28. Antidotes for the Treatment of Pesticide Poisoning

Pesticide	Antidotes
Organochlorines	
Aldrin, chlordane, heptachlor, DDT, HCH, lindane, dicofol, endosulphan	Phenobarbital 0.7 g/day or pentabarbital 0.5g/day. Do not give morphine, theophyline or aminophyline.
Carbamates	
Carbaryl, aldicarb, thiobencarb, propoxur	Inject atropine sulphate 2–4 mg for an adult (0.04–0.08 mg/kg bodyweight for children for 24 to 48 hours. Convulsions and anxiety can be treated with 5 to 10mg of diazepam injected intramuscularly. While keeping the patient fully atropinised, administer also an oxime, if available, e.g. 2–PAM 1000–2000mg IM or IV for adults or 15mg/kg bodyweight for children. Repeat after 1–2 hours.
Organophosphates	
Malathion, methyl parathion, acephate, monocrotophos, oxydemeton, phorate phosalone, quinalphos temephos, DDVP, phosphamidon	Same as carbamates.
Synthetic pyrethroids	
Cyhalothrin, cypermethrin, deltamethrin, fenvalerate, fluvalinate, fenpropathrin	Perform gastric lavage followed by saline cathartic with sodium sulphate solution. Control seizures with injectable diazepam or barbituates.
Mercury compounds	
PMA, MEMC	Inject freshly prepared 100 to 200 ml of sodium formaldehyde sulphoxylate solution intravenously. Give 100 ml of 10% calcium gluconate solution intravenously for muscular spasm.

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Pesticide	Antidotes
Fumigants	
Ethylene bromide, methyl bromide, ethylene dibromide carbon tetrachloride mixture	Administer artificial respiration. Administer aminophylline 1mg/kg (I.V.) slowly as a loading dose by 0.6mg/kg/hr as a maintenence regime. Furosamide: Adults 40 mg slowly (I.V), children 0.5 to 1.5 mg/kg slowly (I.V.).
Dinitrocompounds	
DNOC, PCP,	Adequate emptying of stomach and the use of activated charcoal is followed by saline cathartic with sodium sulphate solution.
Binapacryl, dinitrophenol dinoseb	Same as above.
Copper compounds	
Copper oxychloride copper sulphate	BAL(Dimercaprol) 3 to 5 mg/kg bodyweight.
Anticoagulants – Rodenticides	
Brodifacoum, warfarin, bromadiolone, coumochlor, chlorophocinone	Give vitamin K1 Phytonadione 15–25 mg to adults and 5–10 mg to children orally in mild cases. In severe cases, give Agnamephyton 5–10 mg to adults, 1–5 mg to children, I.M or I.V.
Bipyridyniums	
Diquat, paraquat	Large doses of vitamin C and E as antioxidants. Avoid oxygen therapy for first 48 hours. Give charcoal 50g in 15O ml of water or 8 beaten egg whites.
Zinc phoshide and aluminium phosphide	Give morphine for relief of abdominal pain, high doses of corticosteroids, blood transfusion for treatment of shock and haemorrhage.
Nicotine	Phenobarbitene sulphate 0.7 g daily.
Arsenic compounds	BAL(Dimercaprol) 3 to 5 mg/kg bodyweight.

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012, page 128.*

Table 29. List of Pesticides along with Chemical Names, LD_{50} and ADI Values

Common name	Chemical name	LD_{50} in rats (mg/kg)	ADI (mg/kg/ day)
Acephate	*N–(methoxy (methlthio) phosphinoyl) acetamide*	945	0.02
Bitertanol	*All – rac-1– (biphenyl–4-yloxy) – 3,3, dimethyl –1-(1H, 1,2,4- triazol-1-yl)-butan –2-ol*	>5000	
Atrazine	*2-Chloro–4-ethylamino–6-isopropylamino–s-traizine*	1869-3080	
Butachlor	*N–Butoxymethyl–2-Chloro-2',6 diethylacetanilide*	1740	
Carbaryl	*1- Naphthyl methylcarbamate*	850	0.01
Carbendazim	*Methyl benzimidazol –2- ylcarbamate*	15000	No ADI
Carbofuran	*2,3,-Dihyro-2,2,dimethylbenzofuran-7-yl methylcarbamate*	8-14	0.003
Chlorothalonil	*2,4,5,6-Tetrachloro-1,3, benzendicarbonirile*	>10000	0.03
Chlorpyriphos	*O,O-DiethylO-3,5,6,-trichlor-,O-2-pyridyl phosphorothioate*	135-163	0.01
Cypermethrin	*(RS)-a-Cyano-3-phenoxybenzyl(1RS)-cis,trans-3 (2,2-dichlorovinyl)2,-2-dimethyl cyclopropanecarboxylate*	4123	0.05
Cyhalothrin	*(RS)-a-Cyano-3-phenoxybenzyl(1RS)-cis,trans-3-(-2-chloro-3,3,3,-trifluoro-1-enyl),2-dimethylcylco-propanecarboxylate* *	-	-
Decamethrin (Deltamethrin)	*(S)-a-Cyano-3-phenoxybenzyl(1R,3R)-3-(2,2,dibromovinyl)–2,2dimethylcyclotropane carboxylate*	135-5000	0.01
Diazinon	*O,O-Diethyl O-2-isopropyl-6- methylpyrimidin-4-yl-phosphorothioate*	300-400	0.002
Dieldrin	*(1R,4S,4aS,5R,6R,7S,8S,8aR,)1,2,3,4,10,10, -hexachloro-1,4,4a,5,6,7,8,a–ocathydro-6,7, epoxy 1,4:5,8,dimethanonaphthalene*	37-87	0.0001
2,4–D	*2,4-D-Dichlorophenoxy acetic acid*	700	0.3
Dichlorodiphenyl trichloroethane (DDT)	*1,1,1,-Trichloro-2,2,-bis(4-chloropheny) ethane*	113-118	0.005
Dichlorovos	*2,2,- Dichlorovinyl dimethyl phosphate (I)*	56-1082	0.004
Dicofol	*2,2,2,-Trichloro-1,1,bis (4,Chloro-phenyl) ethanol*	668-842	0.025
Dimethoate	*O,O-DimethylS-(N-methylocarbamoylmethyl) phosphorodithioate*	215	-
Diuron	*3-(3,4-Dichlorophenyl)-1,1, dimethylurea*	3400	-
Dodine	*1- Dodecylguanidinium acetate*	1000	0.01

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Common name	Chemical name	LD_{50} rat (mg/kg)	ADI (mg/Kg/ day)
Endosulphan	*1,4,5,6,7,7-Hexachloro–8,9,10-Trinorborn-5-en-2,3-ylenebis methylene sulphite*	30	0.0075
Fenitrothion	*O,O-Dimethyl O-4- nitro-m-tolyl phosphorothioate*	890	0.005
Fenvalerate	*(RS)-Cyano-3-phenoxybenzyl(RS)2-(4-Chlorophenyl)-3-methylbutyrate*	451	0.007
Isoproturon	*3-p- Cumenyl –1,1,-dimethyluea*	1800	-
Lindane	*gamma-Hexachlorocyclohexane*	88-270	0.01
Malathion	*Diethyl(dimethoxy phosphinothioylthio) succinate*	1375	0.02
Mancozeb	*Manganese ethylene bis (dithiocarbamate) (polymeric) complex with Zinc salt*	11200	0.005
Metalyxyl	*MethylN-(2–methoxyacetyl)-N-(2,6-xylyl)- DL - alaninate*	669	-
Monocrotophos	*3–MethoxyophosphinoyloxyN-methylisocrotonamide*	14	0.006
Myclobutanil	*2-p- Chlorophenyl-2- (1 H-1,2,4-trizol-1-ylmethyl) hexanenitrile*	1600	-
Methyl parathion	*0,0- Dimethyl 0-4 nitrophenyl phosphorothioate*	14	0.001
Pendimethalin	*N-(1-Ethylpropyl) -2,6-dinitro, -3,4,-xylidine*	1050-1250	-
Permethrin	*(3-Phenoxyphenyl)methyl 3- (2,2- dichloroethenyl)-2,2-dimethy–lcyclopropanecarboxylate*	430-4000	0.05
Phorate	*0,0-DiethylS-ethyllthio- methyl phosphorodithioate*	2-4	0.0002
Phosphamidon	*2-Chloro-2-diethylcarbamoyl-1-methylvinyl dimethyl phosphate*	17	0.001
Propiconazole	*1-[2-(2,4-dichlorophenyl-1, 3-dioxolan-5-propryl-2-yl methyl) –1,2,4-triazole*	-	-
Quinalphos	*0,0-Diethyl 0-2- quinoxali-nyl phosphorothioate*	62-137	-
Triazophos	*O,O-DiethylO-1–phenyl–1H-1,2,4-triazol-3-yl phosphrothioate*	320	0.001

Source: *Agnihotri N.P., 1999. Pesticide Safety Evaluation and Monitoring. Published by All India Coordinated Research Project on Pesticide Residues, Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi–110 012, page 172.*

PESTICIDE DIRECTORY

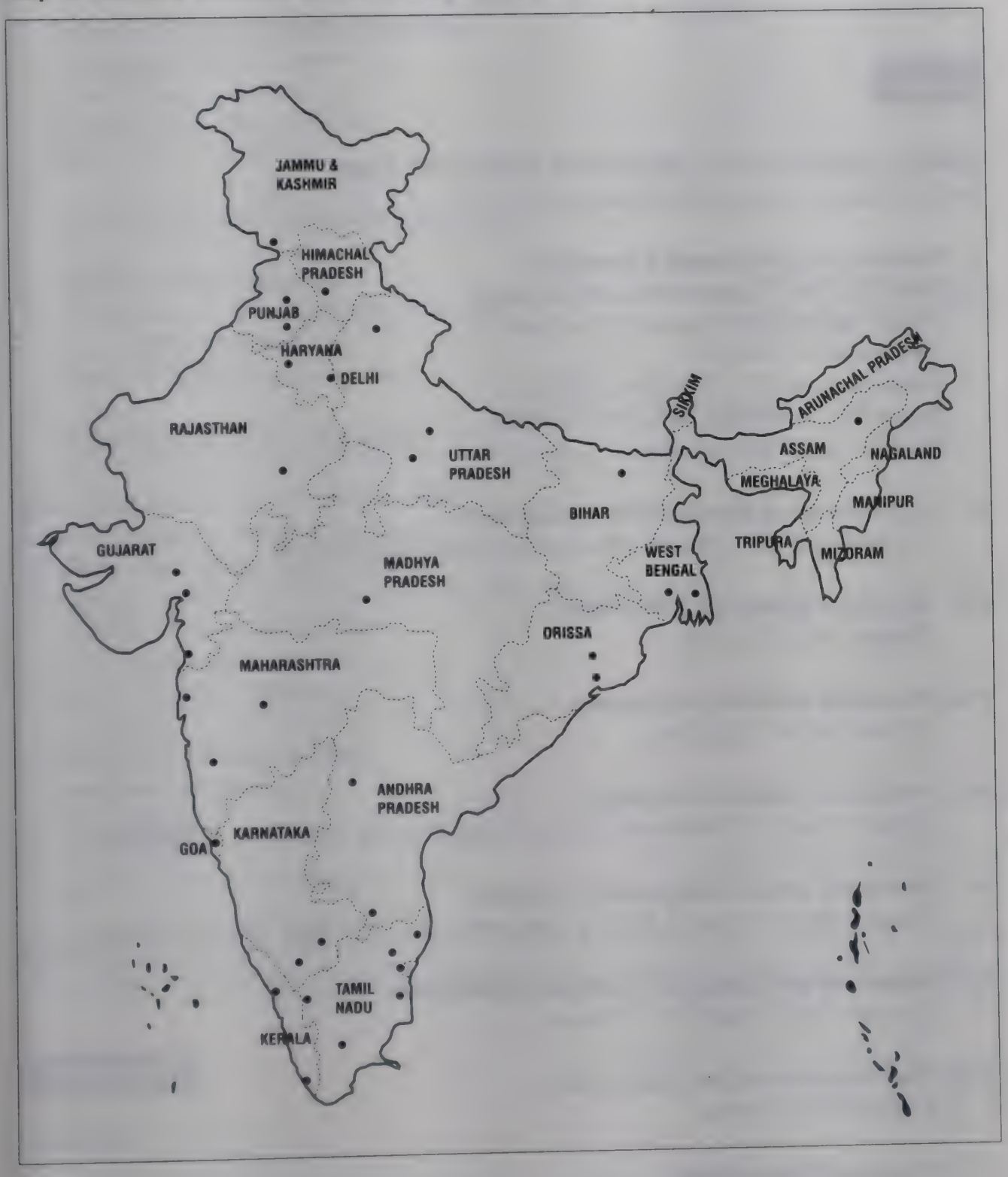
Pesticide Research Laboratories in India

The Map shows states where pesticide laboratories are located in India. In these centres, pesticides are studied for their chemical properties, characteristics, toxicities, fate and behaviour in the environment. In addition, pesticides are qualitatively and quantitatively estimated in food and environment. A few of these labs are involoved in the development of new pesticide moleclues, biopesticides and research in invloving biological control.

List of research centres:

1. Andhra Pradesh: Hyderabad and Tirupathi
2. Assam: Jorhat
3. Bihar: Samastipur
4. Delhi
5. Goa
6. Gujarat: Ahmedabad, Anand and Vapi
7. Harayana: Hissar
8. Himachal Pradesh: Solan
9. Jammu and Kashmir: Jammu
10. Karnataka: Bangalore, Mysore
11. Kerala: Cochin , Thiruvananthapuram
12. Madhya Pradesh: Jabalpur
13. Maharashtra: Mumbai, Nagpur, Pune, Rahuri
14. Orissa: Cuttack, Bhubaneswar
15. Punjab: Ludhiana, Patiala
16. Pondicherry
17. Rajasthan: Jaipur
18. Tamil Nadu: Annamalai, Chennai, Coimbatore, Madurai, Kanchipuram
19. Uttar Pradesh: Hardwar, Kanpur, Lucknow
20. West Bengal: Calcutta, Kalyani

Map 9: Pesticide Research Laboratories in India



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Expert: Prof. B.S. Parmar, Head of Agrochemical Division.

(ii) **Synthetic Pesticide Laboratory**
Expert: Prof. N.K. Roy.

(iii) **Pesticide Residue Laboratory**
Expert: Dr. N.P. Agnihotri.

(iv) **Herbicide Residue Chemistry**
Experts: Prof. G. Kulshrestha, Dr. S.B. Singh, Dr. M. Gopal, Dr. I. Mukherjee.

(v) **Synthetic and Development Chemistry**
Experts: Dr. S.S. Tomar, Dr. C. Devakumar, Dr. R.P. Singh, Dr. D.B. Saxena.

(vi) **Botanical and Synthetic Pesticide Laboratory**
Experts: Dr. S. Walia, Dr. J. Kumar.

(vii) **Phototransformation Laboratory**
Expert: Dr. P. Dureja.

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The Division of Agricultural Chemicals, IARI, is the main centre for pesticide research on agriculture in India. It has facilities to do research in different areas viz. formulation, residue analysis, photodegradation, Quantitative Structure Activity Relationship, biopesticides, organophosphorous pesticide chemistry, anti-resistant insecticide formulations, herbicide and fungicide chemistry. The Division of Agricultural Chemicals is an internationally accepted body for agrochemical research.

(i) Agrochemical Formulation Laboratory
The agrochemical formulation laboratory was initiated in 1972 by Prof. B.S. Parmar, a formulation expert. The laboratory has an immense contribution in the area of pesticide emulsion concentrates. The World Bank funded the National Agricultural Research Programme's sub-project 'Botanical Pesticides' by this laboratory. The Laboratory has published over 200 scientific and professional papers, and has got four patents.

Objectives:
- Development of insecticide synergists of botanical and synthetic origin.
- Development of novel pesticide formulations.
- Study of parameters causing undue degradation in formulation.
- Identification of azadirachtin-rich neem ecotypes of India and the physiochemical and chemical variation in neem ecotypes in relation to their bioactivity.

Achievements:
- Development of: pesticide formulations — floating granule and carbaryl emulsifiable concentrate.
- Indigenous technology for 'water dispensable' granule and 'controlled toxicant release products'.
- Dust and water-dispensable powder formulations of neem.
- Photodegradable formulations of DDT.

- A process for making aza –A–rich powder concentrate.
- A new plant–based mosquito larvicidal formulation.
- Fate of formulation auxiliaries, i.e., surfactant in the environment.
- Toxicant – surfactant carrier compatibility and interaction.
- Analytical methods for the estimation of azadirachtin–A and anionic surfactants in liquid formulations.
- The work on synergists and neem–emulsifiable concentrate is in commercial production.

Experts: *Prof. B.S. Parmar, Dr. D. Choudhury (presently in IIHR, Bangalore)*
Dr. S. Rengasamy, Dr. J. Kumar.

Significant Research Publications

1. Srivastava M., A.V.N. Paul, S. Rengasamy, J. Kumar and B.S. Parmar, 1997. *Effect of neem (Azadirachta indica A. Juss) seed kernel extracts on the larval parasitoid Bracon brevicornis. Wesm.* Journal of Applied Entomolgy. Vol. 121 ; 51–57.

Abstract: The alcoholic and hexane extracts of 17 neem ecotypes of India have been found to be toxic to the egg, larval and pupal stages of the cosmopolitan, external gregarious larval parasitoid *Bracon brevicornis*. In general, the hexane extracts showed higher toxicity against the egg and pupal stages, whereas the alcoholic extracts were more toxic against larvae.

2. Choudhury D. and B.S. Parmar, 1991. *Effect of some common surfactants on emulsion characteristics and biological performance of Insecticide Emulsifiable concentrates.* Pesticide Research Journal. Vol. 31: No.1; 59–61.

Abstract: Accelerated storage of some of the common surfactants, solvents and cypermethrin and temephos toxicants before incorporation in emulsifiable concentrates revealed that the deterioration of emulsion stability due to surfactant was, at best, only as much as any other component of these concentrates. The conclusion was that the diverse types of activity and fate of each surfactant to be used in pesticide formulation needed to be thoroughly investigated.

(ii) Synthetic Pesticide Laboratory

The laboratory was initiated in 1970 by Prof. N.K. Roy, who is presently an Emeritus Scientist. The laboratory has published over 130 scientific publications in international and national journals and has eight patents on pesticides, one of the main contributions being acephate technology.

Objectives:

- Process development using QSAR and Computer Assisted Molecular Designing (CAMD).
- Development of new analytical techniques using high performance liquid chromatography and gas chromatography for the analysis of pesticide residues.
- Development of ecofriendly pesticides.
- Refinements in pesticide residue analysis.

Achievements:

- Developed new type of organophosphorus fungicide effective against the rice fungus, *Pyricularia oryzea*. The new pesticide does not leave any toxic residues in plants, soil and air under field study.
- Developed six indigenous processes for dicofol, edifenphos, acephate, mancozeb, ethephon and chlorobenzilate. The first three processes have been released for commercialization.
- Determination of edifenphos in technical and emulsifiable concentrate formulations by reverse phase liquid chromatography.
- Developed trends in pest management by using ecofriendly pesticides under the globally accepted concept of integrated pest management.

Expert: *Prof. N.K. Roy.*

Significant Research Publications

1. Das S.K. and N.K. Roy, 1998. *Preparation of some novel phosphonamidates and some herbicidal properties*. Pesticide Science. Vol. 52 ; 263 – 67.

Abstract: Fourteen new phosphonamidates have been prepared and screened for their phytotoxicity towards monocotyledonous (wheat) and dicotyledonous plants and herbicidal activity against wild oat. Wheat showed maximum resistance to most of the compounds.

2. Khazanchi R. and N. K. Roy, 1985. *Reverse phase liquid chromatography determination of Edifenphos in technical and emusifaible concentrate formulations*. Journal of Association of Official Analytical Chemists. Vol. 68 : No. 1; 138.

Abstract: A convenient reverse phase liquid chromatographic method has been developed for determination of edifenphos in its technical product and emulsifiable concentrate. The method allows determination of the active ingredient of the formulation without any solvent extraction.

(iii) Pesticide Residue Laboratory

The unit started with a view to monitoring and studying the behaviour of agrochemicals in the environment. Dr. N.P. Agnihotri is the Head of the unit and the Project Coordinator for the All India Coordinated Research Project on Pesticide Residue (AICRP on Pesticide Residues). This unit is the main centre for sixteen AICRP on Pesticide Residues centres located in different parts of India. The Laboratory has conducted an investigation titled 'Contribution of agricultural application of pesticides on the quality of Ganga river and ground water' sponsored by the Ganga Project Directorate.

Objectives:

- Monitoring of pesticide residues in environmental samples.
- Study of the fate of pesticides in field, laboratory and agro–ecosystems. This includes studies on persistence, adsorption and desorption, degradation and bound residue formation of pesticides.
- Study of the environmental fate of new pesticides — their half–lives in soil, water

and sediments, biodegradation and persistence.
- Study of the efficacy of synthetic pyrethroid pesticides and methods to improve efficacy.
- Carrying out supervised trials for evaluation of waiting periods and recommended dosage of pesticides.
- Decontamination and detoxification of pesticide residues from soil, water and food commodities.

Achievements:
- Monitored groundwater contamination by organochlorine insecticide residues in rural areas in the Indo–Gangentic Plain. Results showed that migration of pollutants through groundwater recharge with polluted Ganga river water and monsoon rains carrying undegraded residues downwards from the soil surface are thought to be important sources of insecticide contamination of groundwater in the region. Aldrin residues greatly exceeded the WHO limits.
- Discovery of organochlorine insecticide residues in agricultural soils of the Indo–Gangetic plain. Almost all soil samples were found to contaminated with residues of HCH and DDT. Residues of aldrin, dieldrin, endosulphan and at heptachlor very low concentration were also detected.
- Multiple residues of organochlorines were found in Ganga river water near Farrukhabad. All river water samples were contaminated with DDT and HCH residues, and aldrin, dieldrin, endosulphan and heptachlor were detected in a number of samples. The aldrin residues often exceeded the WHO guidelines for drinking water while heptachlor occasionally exceeded the specific limits.
- Environmental fate of *Lambda*–cyhalothrin in water, sediments and soil surfaces was carried out, since very little was known about it. *Lambda*–cyhalothrin is a new broad–spectrum synthetic pyrethroid used for control of agricultural pests and insect vectors that transmit malaria, cholera, dengue, etc.
- A terrestrial model agro–ecosystem was designed and fabricated to grow plants under controlled conditions simulating a cropped field. The fate of radiolabelled deltamethrin applied to cotton was seen.

Experts: *Dr. N.P. Agnihotri, Dr. V.T. Gajbhiye.*

Significant Research Publications

1. Agnihotri N.P. and A.K. Barooah, 1994. *Bound residues of pesticides in soil and plant — A review.* Journal of Scientific and Industrial Research. Vol. 53 ; 850–861.

Abstract: The use of radiolabelled pesticides has shown that a sizable portion (20 per cent – 40 per cent) of applied activity may remain on soil or plant in non–extractable form (bound residues). It is presented that bound residues generally increases with time and aging makes the binding stronger. The results of the analysis shows that bound residues in soil and plant samples contain both parent compound as well as the degradation product. Evidence indicates that only a small fraction (1 per cent – 10 per cent of the total bound residues) is bioavailable. However, the studies on bioavailability or toxicity are limited to only a few compounds. More research is required to draw any valid conclusion.

2. Pai A.K., P.K. Chhonkar and N.P. Agnihotri, 1999. *Persistence of Pendimethalin and Anilofos in six diverse soils.* Pesticide Research Journal. Vol. 11; No. 2; 132–37.

Abstract: The persistence of soil applied herbicides used for control of weeds in rice, wheat and other crops is of concern with regard to potential damage to succeeding susceptible crops. The persistence of pendimethalin and anilophos in six diverse soils was studied. Dissipation of pendimethalin was less than anilophos in different soils in 120 days. The two herbicides followed a first–order reaction.

(iv) Herbicide Residue Chemistry Laboratory

The herbicide laboratory was developed by Prof. Gita Kulshrestha. The laboratory has evaluated several herbicide schedules in various crops and recommended them for safe usage. These include diverse chemicals like triazines, phenylureas, anilides, dinitroanilines.

Objectives:

- Standardization of methods for residue estimation.
- Development of reclamation methods for land polluted accidentally.
- Studying of the fate of herbicides in agro–ecosystems.
- Monitoring the effect of herbicides on soil microorganisms.
- Studying the dissipation of herbicides in rice crops.
- Studying the bio–transformation of herbicides.
- Studying the photochemical transformation, sorption and leaching, microbial degradation of herbicides and identification of metabolites.

Achievements:

- Determination of the herbicide, isoproturon and its degradation products by HPLC method has been adopted by Bureau of Indian Standards (BIS).
- Evaluated a number of pesticide schedules in cereals, pulses, oilseeds and vegetable crops from the toxicity angles. Pesticides included 15 herbicides and one insecticide.
- Evolved the methods of decontamination and reclamation of land polluted accidentally with triazines.
- Evaluated environmental impact of pesticides such as carbaryl, isoproturon and butachlor on soil microbial population.
- Studies on the herbicide butachlor on soil microbes indicated that butachlor stimulated the microbial activity of rice rhizosphere soil.
- Carried out studies on microbial degradation of pendimethalin, fluchloralin, butachlor and anilophos and identified the metabolites formed in soil. Two new metabolites of butachlor were identified.
- Fungal degradation pathways of butachlor involved dechlorination, C–dealkylation, O–dealkylation, N–dealkylation and cyclization.

Experts: *Dr. G. Kulshrestha, Dr. A.K. Raut, Dr. S.B. Singh, Dr. M. Gopal, Dr. I. Mukherjee.*

Significant Research Publications

1. Raut A.K., G. Kulshrestha and P.K. Chhonkar, 1997. *Effect of Butachlor on microbial soil populations in rice fields.* Toxicological and Environmental Chemistry. Vol. 59; 145–49.

Abstract: Effect of Butachlor on soil populations of bacteria, fungi and actinomycetes following application were evaluated. Butachlor was found to stimulate the microbial activity.

2. Raut A.K. and G. Kulshrestha, 1997. *Biotransformation of Butachlor by soil fungi.* Toxicological and Environmental Chemistry. Vol. 61; 109 –116.

Abstract: *Fusarium solani* and *Chaetomium globosum* isolated from soil enrichment techniques metabolised butachlor in mineral salt solutions. Whereas *F. solani* transformed butachlor into six metabolites, *C. globosum* formed four products. The fungal degradation pathway has been elucidated.

(v) Synthetic and Development Chemistry Laboratory

The Laboratory focuses on the development of synergists (compounds which are not pesticides but enhance pesticidal activity when present along with pesticides) for pyrethrins, carbamates and other groups of pesticides. The unit has developed a novel formulation II for control of insect vectors resistant to DDT. The most significant output from this laboratory is the development of anti–resistant insecticidal formulations.

Objectives:

- Development of synthesis and synergistic activity for pyrethrum compounds.
- Use of major by–products or undesirable constituents from industries for preparation of other compounds with pesticidal properties.
- Investigation of plant products as an alternative for synthetic compounds.

Achievements:

- Termite control and strategies to overcome problems associated with them.
- Synergism of alpha–HCH with n–methyl carbamates.
- Synthesis and bioactivity of some phenyl ethers and amines from alpha–HCH, a major by–product of the lindane industry.
- Synthesis and antifungal activity of fatty acid semithiocarbazides.
- Developed methods for preparation of anti–resistant insecticide preparations. Novel DDT formulation I & II for control of insect vectors resistant to DDT.
- Synthesized nematicidal compounds from alpha–HCH.

Experts: *Dr. S.S. Tomar, Dr. C. Devakumar, Dr. R.P. Singh, Dr. D.B. Saxena.*

Significant Research Publications

1. Tomar S.S., 1995. *Synthesis and bioactivity of some phenyl ethers and amines from alpha–HCH. In: Pesticides, Crop Protection and Environment.* Oxford and IBH Publishers, New Delhi, pp. 347–54.

Abstract: Dumping of unwanted industrial by–products or waste materials in the environment is a major source of pollution. Proper use of such materials reduces xenobiotic load on the environment and also improves economic viability on the industry. The present article demonstrates the use of alpha–HCH, a major by–product of the lindane industry, for preparation of few ethers and amines which have been found to be bioactive.

2. Biswas M.C. and R.P. Singh, 1995. *Synthesis and antifungal activity of fatty acid semithiocarbazides.* Pesticide Research Journal. Vol. 7: No. 1; 32–34.

Abstract: A series of fatty acid semithiocarbazides have been synthesized by a three–step synthesis and assayed for their antifungal activity against *Rhizoctonia bataticola*. The data shows that most of the compounds synthesized exhibited inhibition of fungal growth at a 1000ppm dosage.

(vi) Botanical and Synthetic Pesticide Laboratory

The unit lays emphasis on the use of plant–based products. The focus is on the synthesis of agrochemicals that are benign in the environment.

Objectives:

- Development of new environmentally friendly agrochemicals from plants.
- Structure modification and optimization of lead phytochemicals.

Achievements:

- Synthesized a new insecticide synergist, piperonal oxime N–O– alkyl ether having a better activity than the commercial insecticide synergist activity.
- Synthesized two oxime ethers as new insect bioregulators and also a group of novel pyrethroid type oxime esters as potential insecticides.
- Developed bench–scale know–how for the manufacture of technical azadirachtin powder(biopesticide from neem).
- Stability and bioefficacy of azadirachtin was considerably enhanced using biostablizers/antioxidants from turmeric.
- Generated useful basic information on light–induced transformation affecting the fate of pesticides in the environment.

Experts: *Dr. S. Walia, Head, Dr. J. Kumar, Dr. S. Dhingra, Entomology Division.*

Significant Research Publications

1. Datta S. and S. Walia, 1996. *Synthesis and bioregulatory activity of buprofezin–related thiourea analogues against fifth instar nymphs of Dysdercus koenigii.* Pesticide Research Journal. Vol. 8: No.1; 38–42.

Abstract: Some of the degradation products of buprofezin, a new insecticide–cum–insect growth regulator, which are likely to be encountered as its metabolites, have been synthesized. Among the urea and thiourea analogues tested, a few exhibited insect growth regulatory activity against *Dysdercus koenigii*.

2. Chowdhury H., V.S. Saxena and S. Walia, 1998. *Synthesis and insect growth regulatory activity of alkoxy substituted bezaldoxime ethers.* Journal of Agriculture Food Chemistry. Vol. 46: No. 2; 731–36.

(vii) Phototransformation Laboratory

The focus of the laboratory is to study the light–induced transformation of a number of conventional and new pesticides in soil, water and plant surfaces, both under natural and simulated environments. The work involves the isolation, identification

and characterization of a large number of photoproducts and the establishment of their pesticidal activity and toxicological significance.

Objectives:

- Light–induced transformation of pesticides.
- Development of new techniques for the analysis of pesticides in technical and formulated products.
- Superoxide mediated dehalogenation and dehydro–halogenation pathways of pesticide degradation.

Achievements:

- Synthesized a number of photoproducts/ metabolites of various pesticides. In addition, synthesized a number of organphosphorous compounds as insecticides and fungicides.
- Developed an indigenous process for triadimefon, a triazole fungicide and a non–MIC route for sulfonylurea herbicides.
- Developed bench–scale know–how for efficient and economic conversion of inactive HCH isomers to trichlorobenzenes.
- A novel method was standardized for stabilization of quinalphos and unstable natural and synthetic pyrethroids.
- Developed an indigenous technology for removal of 25 per cent–30 per cent technical azadirachtin–A from neem seed kernel and also a method of isolation up to 90 per cent of pure azadirachtin–A. The unit also developed a technology for thiophanate methyl.

Experts: *Dr. P. Dureja, Dr. A.K. Bhattacharjee.*

Significant Research Publications

1. Bhattacharjee A.K. and P. Dureja, 1999. *Light induced transformation of Tribenuron – Methyl. Chemosphere*. Vol. 38: No. 4; 741–49.

Abstract: The paper deals with the result of photochemical transformations of tribenuron–methyl, in the presence of compounds which are representative model substances for the plant cuticle constituents.

2. Kaur, A. Kumar and P. Dureja, 1996. *Separation of endosulphan and its major metabolites by GC and HPLC*. Biomedical Chromatography. Vol. 11: No.1; 33–35.

2. DIVISION OF ENTOMOLOGY

Indian Agricultural Research Institute
New Delhi – 110 012.

The Division works on the impact of the pesticides on the various pest species: toxicity of the pesticide, resistance development to insecticides, the effect of synergism and the detoxifying mechanisms.

Objectives:

- Bioassay to evaluate lethal concentration ($L.C._{50}$) for different pesticides, and evolving suitable bioassay technique for baseline data in detecting resistance level.
- Study insecticide resistance to different pesticides.
- Study metabolism of insecticides.
- Study enzyme–insecticide interaction, viz. acetylcholine metabolism in insects in relation to insecticide action, carboxylesterases.
- Evaluate impact of physico–chemical properties of diluents on toxicity in different formulations and development of better formulations.

Achievements:

- Discovered significant differences at the acetylcholinestrases catalytic sites for different species of organisms.
- Discovered insecticides do have an 'inducer effect' and that this 'inducer effect' constitutes a real danger from the environmental pollution point of view.
- For the first time in the country, resistance to pyrethroids was reported.
- A diagnostic dose for monitoring pyrethroid and organophosphorous resistance in *Helicoverpa armigera* has been worked out.
- Developed and patented anti–resistant formulation technology to encounter insecticide resistance in pests of medical and agricultural importance.

Experts: *Prof. P. Swarup (retired), Dr. S. Dhingra, Dr. A. Phokela, Dr. V.S. Saxena (retired).*

JAWAHARLAL NEHRU UNIVERSITY (JNU)

1. School of Environmental Sciences

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The School of Environmental Sciences, JNU, is one of the premier institutes in India, developed with a view to studying the immediate and long–term environmental problems in India. The school has an infrastructure and expertise to conduct multidisciplinary research on various environmental problems in India. Prof. A. K. Bhattacharyya initiated research on pesticide science in the School of Environmental Sciences in 1983, which focuses on the effect of a few herbicides on plants and monitoring of pesticides in the environment.

Objectives:

The unit headed by Prof. Bhattacharyya conducts research in the following areas:

- The influence of herbicides and fungicides on plant growth and development.
- Identification and characterization of domestic as well as industrial wastes of Delhi and their management.
- Environmental aspects of land application of sewage effluents and their management.
- Monitoring of pesticides in river water and sediments.

- Air quality and source inventory survey of Delhi area.
- Environmental problems of tailings in Khetri copper mining areas and their management.
- Environmental impact assessment.
- Recycling of sewage effluent and flyash on land.

Achievements:

- Research on trends in chlorinated pesticides and polychlorinated biphenyl levels in the Yamuna river sediments.
- Monitoring influences of herbicides like captan and brassicol on plant growth and development.

Expert: *Prof. A.K. Bhattacharyya, Head.*

Significant Research Publications

1. Sethi P.K., A.K. Bhattacharyya and A. Sarkar, 1999. *Current trends of some organochlorinated pesticides in Yamuna river sediments in and around Delhi.* Environment Pollution Control Journal. Vol. 2 : No. 3 ; 40–43.

Abstract: Organochlorinated pesticides viz. DDT, HCH and cyclodiene compounds have been detected in the sediment samples of the Yamuna river around Delhi during three seasons, namely, pre–monsoon, monsoon and post–monsoon. Five sample sites were selected for the purpose of the study. Among organochlorine pesticides detected, t–DDT was the most predominant in the sediments of the river Yamuna. The Najafgarh site was found to be carrying the maximum load of pollutants, exceeding the permissible limits.

2. Bhattacharyya A.K. and R. Narayanan, 1984. *Some studies on Pisolithus tinetorius invitro and invivo as influenced by Captan and Brassicol (PCNB).* Proceedings of the 6th North American Conference on Mycorrhiza held at Beno, Oregon, USA, July 24–29, 1984.

2. School of Life Sciences

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The School of Life Sciences, JNU, is a multidisciplinary research centre in biological sciences in India. The school has a number of disciplines — immunology, biochemistry, molecular biology, neurobiology are a few of the areas. Work on pesticide science is conducted at Dr. B.C. Tripathy's laboratory. It is the only unit in the centre which conducts research on pesticide science in addition to other areas of research. The research on pesticide science is confined to photodynamic herbicides. Photodynamic compounds are toxic as they produce active oxygen species which react with organic compounds which are essential for life. The compounds

which are meant to maintain the integrity of the cell membrane are very sensitive to photodynamic compounds.

Objectives:

- Development of photodynamic herbicides, the study of their mode of action, characterization of herbicide–binding proteins.
- Study of the physiology and biochemical processes associated with photodynamic damage.
- Study of the action spectrum of 5 – aminolevulinic acid induced photodynamic damage.

Achievements:

- Research on photodynamic damage of cucumber chloroplasts.
- Stress in cucumber seedlings treated with the herbicide, acifluorfen.

Expert: *Dr. B.C. Tripathy, Head.*

Significant Research Publications

1. Chakraborty N. and B.C. Tripathy, 1992. *Acid–induced photodynamic damage of cucumber (Cucumis sativus) chloroplasts*. Plant Physiology. Vol. 98 ; 7–11.

Abstract: Cucumber (*Cucumis sativus*) plants were sprayed with 20 millimolars of 5 – aminolevulinic acid and then incubated in the dark for 14 hours. The intact chloroplasts were isolated from the above plants in the dark and were exposed to weak light. Within 30 minutes, photosystem II activity was reduced by 50 per cent.

2. Gupta I. and B.C. Tripathy, 1999. *Oxidative stress in cucumber (Cucumis sativus) treated with Acifluorfen.* Z. Naturforsch. Vol. 54c; 1–11.

Abstract: Illumination of acifluorfen–sprayed and 14 hour–dark–incubated cucumber seedlings with cool white fluorescent light caused over accumulation of protoporphyrin IX and severe oxidative stress which resulted in seedling death within 72 hours.

MALARIA RESEARCH CENTRE (MRC)

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The Malaria Research Centre (MRC) was established in 1977 by the ICMR in an effort to strengthen research on malaria and to meet the threat posed by the resurgence of malaria. Broad areas of research at the Centre are vector biology and control, genetics, cellular and molecular biology, parasitology, epidemiology, pharmacology, immunology and biochemistry.

Objectives:

- To conduct basic and applied research on malaria.
- To advise on government policy matters.
- Participate in operational research, transfer of technology, health assessment and epidemiological investigations.
- Manpower development.

Achievements:

- Research on biochemical mechanisms of malathion resistance in Indian mosquitoes.
- Research on resistance to *Bacillus sphaericus* in *Culex quinquefasciatus.*
- Evaluation of formulation of mosquito larvicidal agent BIOCID–S from *Bacillus sphaericus* 1953M viz. HIL–8, HIL–9 and HIL–10 in the field showed that HIL–9 fared much better and in several instances high mortality (more than 90 per cent) of *Anopheles* larvae was maintained up to one week. With *Culex*, the high organic pollutants of the habitat lowered the persistence of BIOCID–S.
- Bioenvironmental control of malaria strategy was found feasible, appropriate and sustainable in the long run and made economic sense.
- Evaluating impact of malathion thermal fogging on mosquito populations in Delhi and its place in malaria control.
- Developing insecticide impregnated ropes as mosquito repellents.
- Bioefficacy of neem products against mosquito larvae showed poor larvicidal activity but some of these products showed good insect growth regulators.

Experts: *Dr. S.K. Subbarao, Director, Dr. P. K. Mittal*
Dr. V.K. Dua – from MRC's Field Station at Haridwar, Uttar Pradesh,
Dr. M.A. Ansari, Dr. R.K. Razdan, Dr. K. Raghavendra, Dr. T. Adak.

Significant Research Publications

1. Subbarao S.K. and V.P. Sharma, 1994. *Strategies for Malaria Vector Control in India. In: Tropical Disease Molecular Biology and Control Strategies*, eds. S. Kumar, G.K. Sen, G.P. Dutta and R.N. Sharma. Publication and Information Directorate, New Delhi, pp. 377–386.

Abstract: Field demonstration of bioenvironmental control of malaria in different ecological and epidemiological situations established that insecticides were not needed in all situations and alternative methods were equally effective and economically viable in the control of malaria.

2. Ansari M.A., V.P. Sharma, R.K. Razdan and P. K. Mittal, 1990. *Evaluation of certain mosquito repellents.* Indian Journal of Malariology. Vol. 27 ; 57–64.

Abstract: A study was carried out to evaluate the efficacy of commercially available mosquito repellent preparations and devices. Results showed that none of the repellents tested provided absolute protection against mosquito bites. Among electrical devices, Good Bye and Casper were marginally superior to Good Knight and Knight Queen.

UNIVERSITY OF DELHI

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The Department of Zoology, University of Delhi was recognised as the Centre of Advanced Studies by the University Grants Commission for its outstanding research contribution. The research on pesticide toxicology was initiated in the early 70s by Prof. M.K.K. Pillai, focusing on multidisciplinary research on pesticide toxicology which includes pesticide monitoring in biotic and abiotic environments, viz. monitoring pesticides in air, rain, water, dust and in human tissues, precise qualitative and quantitative studies on the fate of pesticides in the tropical soils by using radiolabelled pesticides, effect of pesticides on non–target organisms, bioaccumulation studies and biochemical mechanisms of resistance of pesticides. In 1984, the *International Atomic Energy Agency(IAEA),* selected the toxicology research unit as a centre from India for a sponsored project to investigate the fate of radiolabelled pesticides in soils and monitoring hexachlorobenzene in the environment.

Objectives:
The pesticide toxicology unit focuses on three aspects: a) insecticide resistance, b) monitoring of pesticides and c) behaviour of pesticides in tropical soils. The details of the objectives are mentioned below:

- Vector resistance to insecticides – to study the biochemical mechanisms involved in the process of mosquito resistance to insecticides ; counter measures to minimize resistance.
- To carry out irritability and toxicity tests against different species of mosquitoes.
- To study the ovicidal activity of insecticides.
- To monitor pesticides in soil, water, air, dust, rain, terrestrial animals like earthworms, snakes and birds, and aquatic animals like clams and fishes and human samples like fat, breast milk and blood.
- To research bioaccumulation and trophic transfer of pesticides in the food chain.
- To monitor impact of pesticides, viz., DDT and HCH residues on soil nematodes.
- To research transfer of pesticides from human primagravid (first delivery) and multigravid (second and subsequent deliveries) mothers to the newborn infants during gestation and lactation periods.
- Field and laboratory studies on dissipation, persistence and metabolism of pesticides in tropical climates.
- Bound pesticide residues and their bioavailabilty to animals.

Achievements:

- Discovery that both DDT and HCH dissipated more rapidly under the Indian subtropical climate than reported for temperate regions and the dissipation of both the pesticides was largely due to volatilization. Unlike temperate conditions, the tropical climates with high humidity, diverse microbial populations in the soil, high temperatures and rainfall favoured loss of DDT and HCH from tropical environments.

- Monitoring of airborne dust in Delhi showed DDT concentration three times greater than HCH concentration.
- Regular monitoring of air from three different sites in Delhi showed higher HCH concentration in air than those of DDT, in the survey.
- Monitoring of DDT and its metabolites, HCH and its isomers, hexachlorobenzene, aldrin and dieldrin in environmental and human samples from Delhi and Faridabad.
- The Acceptable Daily Intake (ADI) of DDT through breast milk, in infants from Delhi was found to be 42 times greater than the ADI recommended by WHO.
- The bioavailability of bound residues of DDT and HCH in soil to gram, maize and rice plants indicated that plants accumulated 12 – 24 – fold more DDT and four to 10–fold more HCH, when grown in soil containing both bound and extractable residues. Also, bound residues of DDT and HCH are mobilised to extractable forms in the soil upon aging. In another study, it was found that earthworms facilitate steady mobilization of soil bound residues to readily bioavailable labile forms.
- Role of mono–oxygenases as a mechanism of resistance to synthetic pyrethroid, deltamethrin in larvae in three species of mosquitoes, showed a significant correlation with mono–oxygenase activity and larval LC_{50} to deltamethrin in various strains of all the three species of mosquitoes.
- Laboratory tests performed on the larvae and adults of four species of mosquitoes, with synthetic pyrethroid, K–ornithine (deltamethrin) indicated high larvicidal and adulticidal activities of the insecticides against all the three species of mosquitoes. The females of all the four species showed irritant behaviour when exposed to the pesticides. The available evidence suggest that this pesticide can be a very effective mosquito control agent.
- The ovicidal activity of permethrin and deltamethrin when compared showed deltamethrin to be 10 times more toxic to mosquito eggs than permethrin. The age of the egg and duration of treatment also influenced the insecticidal activity.

Experts: *Prof. M.K.K. Pillai, Head, Dr. C.P. Kaushik (monitoring of pesticides, dissipation of pesticides, effect of pesticides on non–target organisms), Dr. T. Samuel (dissipation of pesticides using tracer techniques), Dr. A. Thomas (insecticide resistance), Dr. A. Verma (bioavailablity of bound pesticides using tracer techniques), Dr. S. Kumar (insecticide resistance), Dr. A. Nair (pesticide monitoring and dissipation of pesticides using tracer techniques), Dr. A. Sahgal (insecticide resistance), Dr. K. Raghavendra (insecticide resistance).*

Significant Research Publications

1. Pillai M.K.K., 1996.*Vector resistance to insecticides*. Proceedings of National Academy of Sciences. Vol. 66B; 77–97.

Abstract: Rapid development of resistance to insecticides by insect vectors of human diseases during the past 50 years has jeopardised vector control programmes. More than 160 species of vectors have become resistant to major groups of pesticides. In addition, the spread of cross–resistance and multi–resistance among vectors has further restricted the choice of insecticides for vector control. Management of resistance involves developing strategies to minimize resistance

development so that insecticides can be used as useful components in integrated vector control programmes.

2. Nair A., T. Samuel and M.K.K. Pillai, 1992. *Behaviour of DDT in three soils exposed to solar radiations under different conditions*. Pesticide Science. Vol. 34 ; 333–340.

Abstract: Volatilization, mineralization, degradation and binding of soil–applied radiolabelled DDT [14 C] were studied in three different soils from tropical regions of southern India. These soils were subjected to solar irradiation and flooding for a period of 42 days. The data indicate that volatilization was significantly influenced by solar radiation and flooding to a much greater degree than by differences in soil properties. Binding of DDT to soil was significantly increased by flooding the soil, thus leaving up to 33 per cent of the initial DDT as bound residues in the nursery soil.

The Insect Biochemistry Laboratory
Pesticide research is also conducted in the laboratory; however, the focus of the laboratory is on insect biochemistry.

Experts: *Prof. H.C. Agarwal, Dr. Uday Kumar, A. Kumari, Dr. D.K. Singh, Dr. P. Menon.*

Significant Research Publications
1. Kumar U. and H.C. Agarwal, 1992. *Fate of mancozeb in eggplants during summer under subtropical conditions*. Pesticide Science. Vol.36; 121–25.

Abstract: The dissipation pattern of mancozeb showed that the metabolite of ethylenethiourea (ETU) were below maximum permissible limit within 14 days of mancozeb treatment. ETU, an unstable metabolite was degraded to EU (ethylene urea) and this was the predominant metabolite thereafter.

2. Kumar U. and A. Kumari, 1998. *Residues of EBDCs and ethylenethiourea in grapes and apples*. Pestology. Vol.XXII: No.2; 25.

Abstract: Market–basket samples of grapes and apples from Delhi were tested for ethylene bromo dithiocarbamate (EBDCs) and ETU. Although the levels of EBDC were below tolerance limits, however, the presence of these compounds is of concern.

HARYANA

HISSAR

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The CCS Haryana Agricultural University was established in 1971. The centre tests the efficacy of different types of pesticides. The farmers are informed about the recommended dose of various pesticides for a judicious use of these agrochemicals. The centre gets funds by collaborative projects from a number of international companies viz. Monsanto, Bayer, Hoechst, State Government, and the ICAR.

Objectives:

- Testing efficacy of different types of pesticides and recommending their dosage to farmers.
- Recommended doses of pesticides are standardized for different environmental components, particularly edible parts for vegetables and fruits, pulses and crops.
- Monitoring of pesticide residues in soil, water, feed, milk products, fruits and vegetables and human milk with a view to ascertaining levels of contamination.
- Conducting supervised field trials for a pesticide persistence point of view and translocation of pesticides to edible parts.
- Study of the effect of different kitchen processes, for example, washing, boiling, peeling, in reducing the level of existing pesticides.
- Study of the effect of pesticides on soil microbes.
- Evaluating the dietary intake of pesticides in different groups with different types of food habits.

Experts: *Prof. Dr. T.S. Kathpal, Dr. Beena Kumari, Dr. Raj Vir Singh, Dr. V.K. Madan.*

Significant Research Publications

1. Madan V.K., Beena Kumari, Raj Vir Singh, Rakesh Kumar and T.S. Kathpal, 1996. *Monitoring of pesticides from farmgate samples of vegetables in Haryana.* Pesticide Research Journal. Vol. 8: No.1; 56–60.

Abstract: Forty-six farmgate samples of seasonal vegetables, namely cauliflower, cabbage, pea, brinjal, okra, tomato, bitter gourd, smooth gourd and green and red chillies were monitored for residues of different insecticides applied during their growth period. Residues of monocrotophos, quinalphos, BHC isomers, DDT analogues, and endosulphan were found in cauliflower, cabbage and pea peel samples, whereas, pea grain samples were found to contain monocrotophos and quinalphos. Residues of monocrotophos and endosulphan were found in one sample of brinjal. Samples of green chillies and red chillies were contaminated with aldrin and dimethoate. Phosphamidon and malathion residues were found in green chillies only. However, the incidence as well as the contamination of pesticides has decreased significantly as compared to the previous years.

2. Kumari Beena and T.S. Kathpal, 1995. *Level of contamination of milk with HCH and DDT in Haryana.* Indian Journal of Animal Sciences. Vol. 65: No. 5; 576–82.

Abstract: Bovine milk samples were collected periodically from September 1991 to 1992 from the Hissar District Co–operative Milk Producer's Union Ltd for ascertaining the contamination of DDT and HCH residues. Analysis of the samples revealed 100 per cent contamination with HCH residues and the beta HCH residues were the dominant

isomer. DDT was present in 12 of the 24 samples. Residues of DDT were present mostly in the form of p, p' – DDT and p, p' – DDE. The rice straw and husk analysed showed 100 per cent contamination. Consumption of contaminated rice straw and other animal feed by milch cows are the possible causes of contamination of milk.

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The Pesticide laboratory at the GJU was established by Prof. C.P. Kaushik, in the mid–1990s. Although the pesticide laboratory is in its developmental stages, it has taken a multidirectional approach to study problems related to pesticides. The unit has made contributions to issues related to the effect of pesticides on the mammalian system in different pathological conditions, the degradation of pesticides in soil, the effects of pesticides on non–target organisms, the role of soil microbes and the monitoring of water in the state of Haryana.

Objectives:

- Monitoring of pesticides in environmental components — food commodities and human samples.
- Toxicity studies — effect of pesticides on different pathological states such as hypoglycaemic and hyperglycaemic conditions, protein deficiency and diabetic conditions, histopathological and biochemical.
- Pesticide degradation studies in subtropical conditions.
- Microbial studies involving identification and characterization of microbes responsible for degradation and HCH residues in soil.

Achievements:

- Monitoring of airborne pesticides in dust, air and rainwater in Delhi.
- Assessment of infant exposure to chlorinated pesticide residues through contaminated mother's milk in Haryana.

Experts: *Prof. Dr. C.P. Kaushik, Dean and Head, Dr. Anubha Kaushik.*

Significant Research Publications

1. Kaushik C. P., 1989. *Loss of HCH from surface soil layers under subtropical conditions.* Environmental Pollution. Vol. 59 ; 253–64.

Abstract: The loss of HCH at an application rate of 25 kg/hectare was studied under field conditions from two surface soil layers, each of 7.5 cm, at two sites in Delhi. The half–life of HCH was 17 and 25 days for the upper and lower 7.5 cm, layers, respectively. The loss was initially greatest initially at both the sites, and was faster in wet soil than in dry soil.

HEALTH CELL
LIBRARY

2. Kaushik C.P., 1991. *Dry aerial fallout of organochlorine insecticide residues in Delhi, India*. Environmental Pollution. Vol. 71 ; 83–86.

Abstract: Monitoring of airborne dust in Delhi during May and July revealed residues of DDT and HCH residues. The concentration of DDT was almost three times greater than that of HCH.

HIMACHAL PRADESH

SOLAN

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The Y.S. Parmar University of Horticulture And Forestry started pesticide research from 1984 onwards when it was made as one of the centres for the All India Coordinated Research Project on Pesticide Residues (AICRP). It has contributed to various aspects of pesticide research. viz. from monitoring of pesticide residues, persistence of pesticides, and methods for decontamination of pesticides from food commodities. In the past decade, the unit has been regularly monitoring pesticides. Since 1985, the residue section has monitored and analyzed 1157 samples of apple, tomato, capsicum, cabbage, cauliflower, infant formula, bovine milk, desi ghee and mushroom from different parts of Himachal Pradesh. These samples were tested for different pesticides, namely, organochlorines, organophosphorous, ethylene bis–dithiocarbamate, copper and carbendazim fungicides. In addition to monitoring pesticides, the unit at YSPUHF has been studying the role of detergents used for removal of pesticides.

The studies at the unit indicate that there has been a significant reduction in pesticide residues in samples collected after 1996. It may be due to an increase in the cost of pesticides, a reduction in productivity and greater awareness amongst farmers.

Objectives:

- Assess the extent of pesticide residues in different agro–substrates, like apple tomato, mushroom, brinjal, capsicum, cabbage and cauliflower.
- To determine the dissipation rates of pesticides in different food crops and safe waiting periods.
- To conduct a total diet analysis to study pesticide residue intake. This includes analysis for pesticides in water, milk and milk products.
- Study of the effect of processing and fermentation on pesticide residues in juice

and jam making.
- Study the role of detergents permitted for use on food for removal of pesticides.
- To determine the bioefficacy of pesticides in fruits and vegetables.
- To study the metabolism of a select group of pesticides by bacterial cultures.
- Evaluate some pesticides for their intrinsic and field toxicities.

Achievements:
- Devised very sensitive analytical technique for dithiocarbamate pesticide residues and carbendazim. A head space method has been devised for chloroform in freeze dried food commodities.
- Standardized techniques for multi–residue pesticide analytical technique in fruits, vegetables and other food commodities.

Experts: *Dr. A. Nath, Head of the unit, Dr. I.D. Sharma, Dr. J.K. Dubey, Dr. S.K. Patyal.*

Significant Research Publications

1. Dubey J.K., S.K. Patyal and A. Nath, 2000. *Pesticide residues in food commodities – a survey report.* In: Proceedings of International Conference on Processed Food for 21st Century. Organised by the Department of Food Technology and Biochemical Engineering, 14 – 16, January 2000, Calcutta.

2. J.K. Dubey, N. Kumar, S.K. Patyal and A. Nath, 1999. *Monitoring of dithiocarbamate residues as methyl xanthate in apple and tomato.* Pesticide Research Journal. Vol. 11 : No. 2 ; 225–28.

JAMMU & KASHMIR

JAMMU – TAWI

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The Department of Biotechnology has worked upon the ability of microorganisms to decompose, degrade and detoxify certain pesticides. A few strains of *Pseudomonas* species of bacteria can grow on organochlorine pesticides like HCH (formerly known as BHC), and utilise the pesticide as a source of energy. However, this activity is not sufficient to match the enormous quantity of pesticides accumulated over the years. Hence, it is imperative to identify genes which can perform this decontamination activity, make clusters of such genes by appropriate manipulations in the bacteria, and try to enhance their ability to degrade these pesticides.

Objectives:

- The decontamination of the pesticide, HCH, from the soil by manipulating the genes of soil microorganisms, using the process of biotechnology.

Achievements:

- The centre has located extrachromosomal location of HCH degradative genes in two species – *Pseudomonas ovalis* and *Pseudomonas tralucida.*

Experts: *Dr. G.N. Qazi, Head, Dr. S. Johri, Dr. C.L. Chopra.*

Significant Research Publications

1. Johri S., G.N. Qazi, and C.L. Chopra, 1991. *Evidence of plasmid mediated dechlorinase activity in Pseudomonas sps.*

Abstract: Presence of plasmid in HCH™ culture and loss of degradative pathway and physical presence of plasmid upon curing indicate extrachromosomal location of HCH degradative genes in *Pseudomonas ovalis*. Furthermore, the HCH™ degradation determinant of strains *Pseudomonas ovalis* and *Pseudomonas tralucida* could be transferred to cured or to other HCH negative Pseudomonads by conjugation without the transfer of any chromosomal marker.

Note: The centre had been focusing on this aspect of research till 1992. However, the centre had to abandon pesticide research as it was not in the mandate of RRL and also there was a paucity of funds to work in this area.

UNIVERSITY OF JAMMU

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The Department of Bioscience has no pesticide unit as such; however, work on the effect of pesticides on the growth of pulses and crops are investigated by the department.

Objectives:

- Study the impact of pesticides on nodulation of pulse crops.
- Research on the nitrogen economy of soils, *vis–à–vis*, pesticides.
- Assess impact of pesticides on plants, morphology, physiology and reproduction.
- Monitor pesticide residues in crops.

Experts: *Dr. S. Kant, Dr. A. Raina, Dr. R.K. Rampal.*

2. Department of Environmental Sciences
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The Department of Environmental Sciences is a new centre and is in its formative stages of development. It is building an infrastructure and a laboratory to conduct pesticide research. The centre plans to work on the impact of pesticides on plants and monitor pesticide residues in plants and other environmental components.

Objectives:

- Impact of endosulphan, bovistan and chlorpyriphos on the development of gram *Cicar arietirum* i.e., from its germination till its maturation. This includes the effect of the pesticides on the physiology, morphology, reproductive ability and the yield of the plant.

Experts: *Prof. S.P.S. Dutta, Head; Dr. A. Raina, Dr. R.K. Rampal.*

PUNJAB

LUDHIANA

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The Punjab Agricultural University initiated pesticide research in 1968 with an USDA programme. Since then it has been working on different aspects of pesticide research such as pesticide residues, insecticide resistance to insects and pesticide metabolism. The pesticide laboratory, Department of Entomology, conducts the bulk of the pesticide research. Since 1984, the Department has been involved with the All India Coordinated Research on Pesticide Residues (AICRP).

Objectives:

- Monitoring of pesticides in food and food commodities.
- Conducting regular supervised field trials for evaluating safe waiting periods and fixation of tolerance limits.
- Pesticide metabolism studies by using cell suspension cultures.
- Pesticide resistance studies.
- Behaviour and fate of pesticides in the field (dissipation studies).
- Development of simple cost effective methods on detection of pesticides.

- Mass media programmes, educating farmers about safe use of pesticides, safe waiting periods etc.

Achievements:

- The Pesticide Residue Laboratory has fixed the tolerance limits in crops for almost 110 insecticides. More than 4000 samples have been tested for pesticide residues. Pesticide residues are periodically monitored in vegetables and fruits, cereals, pulses, milk and dairy products, animal feed, soil and water in Punjab. The food contamination due to malaria vector control programmes has been researched. The methods of resistance monitoring and status of insecticide resistance, cross resistance, biochemical mechanism involved in the development of resistance and the role of synergists in suppression of insecticide resistance have been evaluated and alternative control methods have been developed. Insecticide resistance in stored grain pests and alternate strategies have been worked out.

Experts: *Dr. B.S. Joia, Dr. A.S. Udeaan, Dr. P.P. Singh, Dr.G.S. Dhaliwal Dr. S.K. Kapoor, Dr. Balwinder Singh, Dr. K.K. Chahal, Dr. R.S. Fattu.*

Significant Research Publications

1. Chahal K.K., B. Singh, B.K. Kang, R.S. Battu and B.S. Joia, 1997. *Insecticide residues in farmgate vegetable samples in Punjab.* Pesticide Research Journal. Vol. 9: No. 2; 256–60.

Abstract: Ninety-six farmgate vegetable samples, namely, cauliflower (23), brinjal (30), cabbage (6) and tomato (25), when analyzed for residues of insecticide last applied to the crop, revealed that about 67 per cent of the samples were contaminated and seven per cent of these contained residues above respective MRLs. Sixty–one vegetable samples were also analysed for the presence of DDT and HCH, which are known to be present in the environment ubiquitously. Thirty-five and 71 per cent samples were contaminated with DDT and HCH residues.

2. Dhaliwal G.S. and Balwinder Singh, 1998. *Pesticidal contamination of the Indian environment: Dimensions and Strategies.* In: Environment and Development, I.S. Grover and A.K. Thukral(Eds), pp. 25–35.

Abstract: India is one of the foremost countries in the world to resort to large-scale use of pesticides for the control of insect pests of public health and agricultural importance. The results of several monitoring surveys carried out in different parts of the country have revealed widespread contamination of different components of the environment with organochlorine insecticides. The magnitude of contamination of milk and milk products, human milk and vegetable oils with DDT and HCH is quite excessive and pervasive. Total dietary intake of DDT and HCH were found to be higher than those reported from other countries. The role of intradomiciliary spray of DDT and HCH under National Malaria Eradication Programme towards contamination of the environment and strategies for pesticide management are discussed.

PATIALA

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The Department of Biotechnology at the Patalia University is one of the very few units in India working on the effect of pesticides on the immune system. Dr. Aruna Bhatia started the immunotoxicology laboratory. Although the immunology centre is fairly new and in its formative stages, it has made an immense contribution on documenting the immunomodulatory effects of a few environmental pollutants.

Objectives:
- Evaluation of host resistance and non–specific cell-mediated immune responses to sublethal and subchronic doses of pesticides.
- Evaluation of sublethal doses of pesticides on a few hematological and non-specific immunological parameters.
- Evaluation of alterations of functional cell-mediated immunity by exposure to pesticides.

Achievements:
- Pesticides like malathion have variable effects on different functions of leukocytes.
- Subchronic and sublethal doses of aldrin may effect non–specific stimulation of cells involved in immune reactions and increase the rate of parasitaemia.

Experts: *Dr. A. Bhatia, Dr. J. Kaur, M. Makkar.*

Significant Research Publications

1. Bhatia A., P. Singh and J. Kaur, 1996. *Effect of sublethal concentration of methyl parathion on some hematological and non specific immunological parameters of mice*. Journal of Environment Monitoring. Vol. 6: No. 2; 123–26.

Abstract: The effect of sublethal doses of methyl parathion (MP), an organophosphorous pesticide, was studied on haematological and non–specific immunological parameters in mice. MP treatment at sublethal concentration decreased total leukocyte count and haemoglobin, but, in contrast, resulted in a dose independent increase in total splenocyte count and complement receptor bearing B lymphocytes.

2. Bhatia and J. Kaur, 1993. *Recent advances in immunomodulatory effects of some chemical pollutants, Insecticide residues in farmgate vegetable samples in Punjab.* International Journal of Environmental Studies. Vol. 45 ;61–70

Abstract: A review containing 85 references from 1987 to 92 is presented. An in–depth and systematic study on immunomodulatory effects of chemicals, e.g.,

pesticides, heavy metals and chemicals of occupational exposure, is recommended, as these chemicals, though employed for the benefit of mankind, may be a health hazard when consumed continually at otherwise subtoxic levels, thus rendering people more prone to new or existing diseases by causing immunosuppression.

UTTAR PRADESH

HARDWAR

MALARIA RESEARCH CENTRE
Indian Council of Medical Research
Industrial Malaria Unit
Health Centre, Sector – III, BHEL
Ranipur, Hardwar — 249 403
Telephone — 4396 (BHEL)

Objectives:
- Monitoring of pesticide residues.
- Bioenvironmental control of malaria.

Achievements:
- Monitoring of pesticide residues in environmental samples such as soils, pond water, bovine milk and human blood and milk samples at Hardwar.
- Bioenvironmental control programme was very successfully tried out over a period of nine years.

Experts: *Dr. V.K. Dua, Dr. C.S. Pant, Dr. G.K. Pathak.*

Significant Research Publications

1. Dua V.K., C.S. Pant, G.K. Pathak and V.P. Sharma, 1997. *HCH and DDT residues in human milk and bovine milk at Haridwar– India*. Indian Journal of Malariology. Vol.34; 126–31.

Abstract: Concentrations of HCH and DDT in human and bovine milk were determined in two areas under malaria control, namely BHEL and Bahadrabad at Hardwar. Statistically significant differences were recorded in levels of both the pesticides. Of the bovine milk samples taken from Bahadrabad, 38.5 per cent had pesticide levels which exceeded the tolerence limit.

2. Dua V.K., S.K. Sharma, A. Srivastava and V.P. Sharma, 1997. *Bioenvironmental control of Industrial malaria at Bharat Heavy Electricals Ltd., Hardwar, India: Results of a nine year study (1987–95)*. Journal of the American Mosquito Control Association. Vol.13: No.3.

Abstract: The study has shown that malaria control in an industrial township through integrated control approach is practical, sustainable and economically feasible and reduces insecticide pollution in the environment.

KANPUR

CHANDRA SHEKHAR AZAD UNIVERSITY OF AGRICULTURE AND TECHNOLOGY (CSAUAT)

PESTICIDE RESIDUE LABORATORY

Nawabganj, Rawatpur
Kanpur – 208 002

The CSA University of Agriculture and Technology started pesticide research initially with the development of pesticide formulation. In 1984, it was made one of the centres for the AICRP. Since then, the centre has contributed on various aspects of pesticide research relevant to the state of Uttar Pradesh. These include monitoring, determination of tolerance limits and supervised trials.

Objectives:

- Monitoring of pesticide residues in vegetables, fruits, water, animal feed, bovine milk and almost all types of human dietary commodities.
- Conducting supervised field trials for pesticide persistence in brinjal, cauliflower, tomatoes, wheat, mustard and groundnut.
- Evaluating Maximum Residue Limit, half–life and LD_{50} in pesticides.
- Testing of pesticide formulation for different agencies and confirming if it is in accordance to Bureau of Indian Standards (BIS).

Experts: *Dr. J.K. Asthana, Dr. M.P. Shukla, Dr. D.D. Tiwari, Dr. R.C. Nigam.*

Significant Research Publications

1. Shukla M.P., D.D. Tiwari, R.C. Nigam and V.P. Saxena, 1999. *Monitoring of pesticide residues from farmgate samples of vegetables*. In Green Protection, Crop Protection and Safety Evaluation. N.P. Agnihotri, S. Walia and V.T. Gajibhiye (eds.), pp 141–42.

LUCKNOW

INDUSTRIAL TOXICOLOGY RESEARCH CENTRE (ITRC)

Pesticide Toxicology Unit

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The Industrial Toxicology Research Centre is the premier toxicological research centre, under the Council of Scientific and Industrial Research. The areas of focus are: biomembrane toxicology, immunotoxicology, dyes and food adulterant toxicology, environmental monitoring, Fibre toxicology, cardiovascular toxicology, devel-

opmental toxicology, neurotoxicology, inhalation toxicology, analytical toxicology and pesticide toxicology.

Objectives:
The Pesticide Toxicology Unit of the ITRC serves as a major centre for pesticide toxicology in the country with studies on the following:

- generation of toxicology data.
- understanding the action of pesticides.
- development of new methods for detection.
- biological and microbial degradation of pesticides.
- monitoring of health hazards of pesticide exposure in agriculture, farmers, sprayers and occupational workers.
- monitoring pesticide residues in environmental, food and biological samples.
- providing training in the area of pesticide toxicology and residue analysis.

Achievements:

- The institute has taken toxicity/safety evaluation programmes for over 100 chemicals for industries, government organizations and national laboratories, with the toxicity data for the purposes of registration of their products.
- It provides support to regulatory agencies.
- It has done safety/toxicity evaluation of biopesticides.
- Several potential toxic pesticides like organochlorines, organophosphorous pesticides, dithiocarbamates and pyrethroids have been studied to understand the mechanism of neurobehavioural and neurotoxicity, reproductive toxicity, including the three generation reproduction study, mutagenicity and carcinogenicity in animals.
- Studies have been conducted to evaluate 'No observed adverse effect level' (NOAEL) of pesticides to derive the safety margin of the chemicals.
- Impact of pesticides on macular degeneration studied.
- Several studies have been undertaken on health records of occupational workers.
- Participated in WHO and FAO sponsored collaborative projects on pesticide residue analysis. Participated in the multicentric programmes on pesticide residue analysis in food material, human milk and duplicate diet under ICMR.
- Involved in pesticide residue analysis programmes under Ganga River Project, National Mission on Drinking Water.
- Engaged in the development of new methods such as ELISA for detection of pesticides.
- Capabilities for the analysis of allethrin, a pyrethroid used in mosquito repellents and azadirachtin, a biopesticide, is in progress.
- ITRC has arranged training programmes on pesticide residue analysis for participants of regional countries in collaboration with the Commonwealth Science Council, London.

Experts: *Dr. P.K. Seth, Director, ITRC, Dr. R.B. Raizada, Head of Pesticide Toxicology Unit, Dr. M.K.J. Siddiqui, Analytical Chemistry Division, Dr. L.P. Srivastava,* Mr. R.A. Kaushal, Dr. M.K. Srivastava, Mr. K.P. Gupta, Mr. R.P. Singh.

Significant Research Publications

1. Srivastava M.K., R.B. Raizada and T.S.S. Dikshith, 1992. *Fetotoxic response of technical quinalphos in rats.* Veterinary and Human Toxicology. Vol.34: No. 2.

Abstract: Technical quinalphos was administered to pregnant rats through 6–20 days of gestation. A few skeletal deformities were noticed. A significant inhibition of acetylcholinestrases activity in foetal brain and placenta indicated possible transmigration to foetuses.

2. Kackar R., M.K. Srivastava and R.B. Raizada, 1997. *Induction of gonadal toxicity to male rats after chronic exposure to Mancozeb*. Industrial Health. Vol. 35; 104– 11.

Abstract: Mancozeb, a fungicide, was orally administered at particular doses and a period of time. There was a significant loss of sperms, degeneration of somniferous tubules and decrease in weight of the epididymis. The study indicated marked biochemical and pathological changes in the gonads of male rats after chronic exposure to mancozeb.

KING GEORGE MEDICAL COLLEGE HOSPITAL

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Neurotoxicological Unit
The Neurotoxicological Unit in the Department of Neurology, KGMS, was initiated by Dr. Devika Nag. The unit emphasises on clinical, neurological and neurophysiological aspects. The unit has published the National Status Report on Neurotoxins (pesticides).

Achievements:
- First one to publish 'epidemic epilepsy due to benzene hexachloride contamination of food from Uttar Pradesh'.
- Documented clinical, neurophysiological, biochemical and behavioural manifestation of chronic pesticide exposure in sprayers of Uttar Pradesh.
- In collaboration with Neurotoxicology Unit, ITRC, Lucknow, documented for the first time – i. Macula damage in retina by the organophosphorous pesticide, Fenthion; ii. behaviour and cognitive dysfunction with chronic exposure to organochlorine pesticides; iii. neurophysiological, i.e., motor and sensory nerve conduction, EEG, P_{300} and biochemical parameters with chronic organaphosphate exposure; iv. absence of abnormal neurophysiology with aluminum sulfide workers; v. human subclinical toxic syndromes with synthetic pyrethrin, and vi. protocols for medical personnel for identification of pesticide toxicity and measures suggested for prevention.

Significant Research Publications

1. Nag D., G.C. Singh and S. Senon, 1977. *Epidemic epilepsy due to benzene hexachloride contamination of food from Uttar Pradesh*. Journal of Tropical and Georgr. Medicine. 129: 229–32.

2. Nag D. , 1996. *Aluminum phosphide poisoning*. International Journal of Medicine. 19–20.

West India

GOA

NATIONAL INSTITUTE OF OCEANOGRAPHY (NIO)

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National Institute of Oceanography, one of the laboratories of the Council of Scientific and Industrial Research, was founded in 1966. The institute carries out research in different aspects of oceanography. The institute has headquarters in Goa and has three regional centres — at Mumbai, Kochi and Vishakapatnam respectively.

The Pesticide Research Laboratory at the NIO monitors the level of pesticide contamination of the marine environment.

Objectives:

- To determine the levels of contamination of different persistent organochlorine pesticides such as HCH isomers, DDT and its metabolites (both para and ortho forms), aldrin, dieldrin and endrin in, the various compartments of the marine ecosystem, viz. water, sediment and biota, and their pathways of input.
- To evaluate the fate and persistence of different organophosphorous pesticides in the marine and estuarine sediments.
- To evaluate the major physicochemical parameters influencing the fate and persistence of organophosphorus pesticides in the marine environment by statistical analyses.

Achievements:

- The levels of contamination of different organochlorine pesticides like HCH, DDT, aldrin, dieldrin and endrin were determined in sediments, water and biota from the marine environment along the east and west coasts of India. Among the isomers of HCH and DDT metabolites, gamma HCH and p,p'–DDE was the most prominent metabolite detected in different sediments of the marine environment.

Experts: *Dr. Ehrlich Desa, Director, Dr. A. Sarkar, Sr. Asst. Director, Dr. M.S. Shailaja.*

Significant Research Publications

1. Sarkar A., R. Nagarajan, S. Chaphadkar, S. Pal and S.Y.S. Singbal, 1997. *Contamination of organochlorine pesticides in sediments from Arabian Sea along the west coast of India. Water Research.* Vol. 31: No. 2; 195–200.

Abstract: The levels of contamination of various organochlorine pesticides such as HCH, DDT, aldrin, dieldrin and endrin were determined in marine and estuarine sediments along the west coast of India. The most predominant metabolites of DDT and HCH in both esturine and the offshore sediments were found to be p,p'–DDE and alpha–HCH, respectively.

2. Sarkar A., 1991. *Evaluation of the major physicochemical parameters influencing the degradation of DDT in marine sediments.* Environmental Pollution. Vol.1 (ICEP–1): No.2; 780–89.

GUJARAT

AHMEDABAD

NATIONAL INSTITUTE OF OCCUPATIONAL HEALTH (NIOH)

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The National Institute of Occupational Health (NIOH) is an internationally recognised laboratory for pesticide research. The institute has done studies pertaining to biological and environmental monitoring of persistent pesticides, experimental toxicological evidence to evaluate their carcinogenic potential, health surveillance, studies amongst workers in unorganized and organized sectors of the pesticide industry, pesticide spray workers, pest control agency workers, warehouses and godown workers and other user groups.

Objectives:

- Biological monitoring of pesticide residues in general population. It undertakes various studies reflecting health effects of these chemicals in high–risk population groups, including formulators, sprayers etc.
- Evaluation of daily dietary intake of DDT and HCH.
- Evaluation of human exposure to persistent insecticides in Ahmedabad.
- Research on cardiac toxicity following short-term exposure to pesticides.
- Study of biochemical modification of enzymes due to pesticides.
- Assessment of location–specific human exposure to agrochemicals.

Achievements:
- NIOH has generated data on the residue levels of different pesticides in various components of the environment and in the general population.
- It is a recognised centre by WHO for occupational health and a collaborative centre for WHO.

Experts: *Dr. H. N. Saiyed, Director; Dr. V. K. Bhatnagar, Dr. R.K. Kashyap.*

Significant Research Publications

1. Saiyed H.N., V.K. Bhatnagar and R. Kashyap, 1999. *Impact of pesticide use in India.* Asian Pacific Newsletter on Occupational Health and Safety. Vol. 6; 66 – 67.

Abstract: The evidence accumulated over the last few decades indicate that the use of such chemicals in agriculture has much greater health consequences and environmental consequences than was originally believed.

2. Kashyap R., L.R. Iyer and M.M. Singh, 1994. *Assessment of location-specific human exposure to DDT and BHC in Gujarat state, India.* International Archives of Occupational Environmental Health. Vol. 65; 381–84.

Abstract: Raw food commodities, water, soil and blood samples were collected from two locations in the Gujarat state. Residues of DDT and BHC were present in both locations.

ANAND

GUJARAT AGRICULTURAL UNIVERSITY (GAU)

Bidi Tobacco Research Station (BTRS)
Chemistry Department
Gujarat Agriculture University
Anand Campus
Anand — 388 110

The Gujarat Agriculture University started research on pesticide residues from 1984 onwards, when it had become one of the centres for the AICRP. The Bidi Tobacco Research Centre conducts research on pesticidal contamination in food and environmental matrices. The monitoring of pesticide residues has shown that the contamination is by the organochlorine group of pesticides.

Objectives:
- Monitoring of pesticide residues in food commodities such as crops, cereals, vegetables, bidi tobacco, groundnut, edible oils, milk and milk products, infant formula, animal feed, and soil and water. Evaluation of daily dietary intake of DDT and HCH.
- Study of dissipation and persistence of pesticides in soil and tobacco crops.

Experts: *Dr. B.K. Patel, Head, Dr. M.F. Raj, Dr. P.G. Shah, Dr. J.G. Talati, Dr. P.S. Patel, Dr. J.R. Patel, Dr. R.B. Patel, Dr. J.R. Patel, Mr. K.D. Diwan.*

Significant Research Publications

1. Patel B.K., M.F. Raj, P.G. Shah, J.A. Patel and J.S. Patel, 1993. *Persistence of Ridomil MZ72WP in tobacco nursery soil.* Tobacco Research. Vol.19; 41–44.
2. Patel B.K., M.F. Raj, P.G. Shah and J.G. Talati, 1989. *DDT and HCH residues in dairy milk in Gujarat.* Gujarat Agricultural University Research Journal. Vol.15; 70–76.

MAHARASHTRA

MUMBAI

CENTRAL INSTITUTE OF FISHERIES EDUCATION (CIFE)

Indian Council of Agricultural Research
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The Central Institute of Fisheries Education (CIFE) was established in 1961. The CIFE has got five sub–stations in Calcutta, Lucknow, Hoshangabad (MP), Karnataka and Rohtak (Haryana) respectively. There is no pesticide unit as such, but sporadic work on aquatic toxicology is conducted.

Objective:

- Conduct basic research in the frontier areas of fisheries science and technology, initiate research programmes in specialized disciplines of fisheries sciences and technology and conduct capsule courses for training fisheries personnel.

Experts: *Dr. S.A.H. Abidi, Director, Dr. S.C. Mukherjee, Joint Director, Dr. S. Datta, (Pesticide toxicology at the Calcutta unit), Dr. U.K. Maheswari (Calcutta Unit), Mr. K. Venkateshvaran (Mumbai Unit).*

Significant Research Publications

1. Maheswari U.K., B.C. Das, S. Paul, S.K. Chouhan and A.K. Yadav, 1988. *Bioassay studies of some commercial organic pesticides to an exotic carp fry, Hypophthalmichthys molitrix.* Journal of Environmental Biology. Vol.9: No.4; 377–80.

Abstract: Observations on bioassay of three organic pesticides, methyl parathion, endosulphan and BHC has been made with carp fry to determine lethal concentration, relative toxicity and the safe concentration. Methyl parathion was found to be very toxic among the pesticides studied.

NAGPUR

NATIONAL ENVIRONMENTAL ENGINEERING RESEARCH INSTITUTE (NEERI)

Water Technology Division
Council of Scientific and Industrial Research
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NEERI does not have a separate pesticide research unit. However, there is a group of people working on pesticide–related problems since 1977 at the Water Technology Division (WTD). The Division monitors the environment for various pollutants and conducts environmental tests for water quality. The focus on pesticide research is particularly on pesticides in drinking water. The WTD lays emphasis on the development of analytical procedures to rapidly detect these pesticides and decontaminate the water from these residues. In addition to studies on pesticides, the unit monitors the concentration of polynuclear aromatic hydrocarbons in water bodies. These chemicals are responsible for taste and odour problems, colour formation and oxygen depletion.

Objectives:

- Environmental monitoring.
- Decontamination technology.
- Development of quality–assurance practices.
- Environmental impact and risk assessment.
- Optimization and process design.

Achievements:

- Analytical techniques have been developed and standardized for the analysis of commonly encountered pesticide residues in water. Baseline data have been established at the national level to identify the magnitude of the problem. Treatment technologies have been developed for the pesticide removal system for a small community and at a domestic level. Work on biodegradation of pesticides is also being carried out.
- Monitoring of halogenated compounds in and around Nagpur city water resources for establishing treatment technologies at water works.
- Development of pesticide removal systems — bioremediation, adsorption, oxidation and coagulation, sedimentation and filtration. The effect of ultraviolet radiation, using titanium dioxide and zinc oxide as photocatalysts was studied for the removal of gamma — HCH and p,p' — DDT in aquatic systems. It was observed that there was a reduction of both the pesticides by 88 – 100 per cent.
- Design of community–level water treatment plant for pesticide removal. The system has been designed for a small community of 1000 people.

- Use of granular activated carbon adsorption was found to be a reliable and effective means of removing organochlorine pesticides from potable water. Data leads to the development of a tap attachable water treatment unit for pesticide removal for application on a domestic scale.
- Environmental monitoring for priority pollutants, viz. pesticides, trihalomethanes, chlorophenols, chlorobenzenes and polyaromatic hydrocarbons in surface waters of a river and a lake.

Experts: *Dr. R. N. Singh, Director, Dr. N. P. Thacker, Assistant Director, Dr. M. V. Vaidya, Dr. A. Rudra, Dr. A. Titus.*

Significant Research Publications

1. Thacker N.P., 1989. *Persistence of an organophosphorous larvicide abate in water. Indian Water Works Association.* Jan–March, p125.

Abstract: To investigate the degree of persistence of abate in drinking water an analytical technique was developed. The recovery of the technique was above 97 per cent. Various sets of experiments have indicated a steady decrease in the abate concentration to a maximum of 98 per cent in fifteen days, in drinking water.

2. Thacker N.P. and J.V. Sapre, 1990. *Studies on the removal of gamma–HCH from drinking water by NUCHAR C–190.* Asian Environment. Vol. 12: No. 1; 20–23.

Abstract: Experiments were conducted to evaluate the adsorption capacity of granular activated carbon NUCHAR C–190 for the removal of gamma–HCH from drinking water at microlevels. A carbon dose twice the weight of lindane, removed 99.5 per cent of 2 mg/L lindane in two hours contact at pH 7.0

PUNE

INSTITUTE FOR TOXICOLOGICAL STUDIES (INTOX)
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INTOX's mission is to provide high quality, reliable research and testing services in the field of safety assessment of chemical and biological products, and to offer better services to the technological and research needs of clients in India and abroad. INTOX is a contractual research organisation, performing a wide range of toxicological studies for agrochemical, biotechnological, pharmaceutical and chemical industries from private and public sectors, who wish to obtain national and international registration of their products. INTOX complies with the principles of Good Laboratory Practices (GLP) and has extended the international quality standard ISO 9002 to all aspects of its operations. The INTOX is approved by the Department of Science and Technology, Government of India.

The centre has the infrastructure and facility to conduct the following tests:

- General toxicity — which include the acute, subchronic and chronic toxicity and the carcinogenicity test.
- Reproductive toxicity — teratology, peri–and postnatal studies.
- Special toxicity studies — neurotoxicity, sensitization, irritancy of skin and mucous membrane, synergism and potentiation.
- Inhalation toxicity — single and multi exposure studies.
- Genotoxicity — mutagenicity, chromosomal analysis and sister chromatid exchange.
- Ecotoxicity — toxicity to fish, alga, daphnia, earthworm, honeybee, pigeon, chicken and quail.
- Field exposure studies on humans and livestock for agrochemicals.
- Health monitoring studies on human volunteers for household pesticides.

Experts: *Dr. P.Y. Naik, Dr. N.S. Deshmukh, Dr. M.P. Pore, Dr. S. M. Katdare.*

Note: Intox has a branch in Mumbai and the address is 14, Ganesh Siddhi, Ram Mandir Road, Babhai, Borivali (w), Mumbai–400 091. Tel– 022–8992036. There are 45 contractual research organizations which generate toxicological data on pesticidal products.

NATIONAL CHEMICAL LABORATORY (NCL)
Council of Scientific and Industrial Research
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The National Chemical Laboratory, Pune, has long been associated with development of the processes for the industrial manufacture of many selected pesticides such as endosulphan, monocrotophos, chlorpyriphos, synthetic pyrethroids, dalapon and a few more. The pesticide laboratory and the entomology department has contributed to a very great extent on the development of controlled release formulation of various pesticides including carbofuran, 2–4D and temephos. NCL is also involved in the search for alternative technologies for pest management, viz. potential pest control agents from plants, or new synthetic molecules such as the insect growth regulators, viz. juvenile hormone analogues. NCL has an established entomology facility for research and development on conventional as well as newer pest control agents. Currently, NCL is engaged in several Government–funded and industrial projects on development as well as effects of conventional and new pesticidal moieties.

Objectives:
The research work on pesticide toxicology is essentially a contribution from the entomology division. The centre works on:

- Toxicology of conventional pesticides.
- Innovative research on behavioural and physiological correlates of conventional synthetic insecticides in context of insect resistance.

- Environmental impact studies.
- Development of alternative technologies for pest management.
- Development of innovative pest / vector management strategies and systems.
- Enhancement of natural enemy action for improved biological control.

Achievements:

- Studied environmental impact of lindane, chlorpyriphos, temephos, synthetic pyrethroids on soil, water and air.
- Developed controlled–release dispensers for regulated delivery of conventional pesticides in water to ameliorate hazards of continuous and indiscriminate application.
- Carried out research on plant based products for their insecticidal properties.
- Developed and modified chemicals such as pheromones and insect growth regulators.

Experts: *Dr. P. Ratnasamy, Director, Dr. R.N. Sharma, Deputy Director and Head of Toxicology Unit, Dr. V.B. Tungikar, Dr. V. Tare.*

Significant Research Publications

1. Sharma R.N., V. Tare, P. Pawar and P.H. Vartak, 1992. *Toxic effects of some plant oils and their common constituents on the Psyllid pest of social forestry tree Leucanea leucoecephala.* Applied Entomology Zoology. Vol. 27: No. 2 ; 285–87.

Abstract: *Leucanea leucoecephala*, a tree used for social forestry, which has been ntensively cultivated in a few south-east Asian countries including India, has shown serious infestation with psyllid *Heteropsyalla cubana*. Since conventional synthetic insecticides are unsuitable, due to cost factors as well as use of tree products such as leaves as fodder by local communities, management alternates for *H. cubana* on *L. leucoecephala* are suggested.

NATIONAL INSTITUTE OF VIROLOGY (NIV)

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The National Institute of Virology is a leading institute for research for virology in India. In the field of pesticide science, the institute has developed expertise in detecting insecticide resistance, which involves standard bioassay, as well as a new approach, which determines the genetic and molecular basis of resistance. Although the institute has a multidisciplinary approach, working on various groups of insects of medical importance, currently the major thrust is on mosquito vectors. This is one of the pioneering institutes in the country where 'Micro–Titre plate enzymes assays' for detection of insecticide resistance in mosquito fleas have been established.

The institute is a WHO collaborating centre for Arbovirus and Haemorrhagic fever reference and research.

Objectives:
In the area of pesticide science, the institute conducts research in the following areas:

- Evaluation of the combined effect of insecticides and insect growth regulators.
- Association of insecticide resistance and enzyme titres in *Aedes aegypti* mosquito.
- Insecticide susceptibility status and enzyme profile in specific species of mosquitoes.
- Biochemical basis of resistance.

Achievements:

- Established micro–Titre plate enzymes assays for detection of insecticide resistance in fleas.
- Dengue virus detection and susceptibility to insecticides.
- Present insecticide susceptibility status of the flea, *Xenopsylla cheopsis* in Maharashtra.

Experts: *Dr. D.T. Mourya, Assistant Director, Dr. G. Geevarghese, Dr. M.D. Gokhale Dr. P.V.M. Mahadev, Dr. A.C. Mishra, Dr. M.A. Ilkal, Dr. K. Banerjee Dr.S. Chakraborti.*

Significant Research Publications

1. Chakraborti S., D.T. Mourya, M.D. Gokhale and K. Banerjee, 1993. *Insecticide susceptibility status and enzyme profile of Aedes albopinctus populations from different localities of Maharashtra state*. Indian Journal of Medical Research. Vol. 97; 37 – 43.

Abstract: Susceptibility status of five populations of *Aedes albopinctus* mosquitoes from Maharashtra state to DDT, malathion, fenitrothion, bromophos, propoxur and deltamethrin was studied and compared with laboratory population. All populations of mosquitoes were highly susceptible to all the pesticides except for DDT.

2. Mourya D.T., M.D. Gokhale and A.C. Mishra, 1994. *Biochemical basis of DDT resistance in Aedes aegypti population from dengue affected area in Shahjahanpur city*. Indian Journal of Medical Research. Vol. 99; 212 – 15.

Abstract: Entomological studies conducted in Jalalnagar, Shahjahanpur city, Uttar Pradesh, India, during an outbreak of dengue in 1992 showed that *Aedes aegypti* mosquitoes were resistant to DDT and had some tolerance to malathion in the adults and the larvae. Biochemical analysis suggested that DDT resistance was related to specific enzymes. Crosses of DDT–resistant and susceptibility strain suggested that resistance was co–dominant (metabolic type).

TROMBAY

BHABHA ATOMIC RESEARCH CENTRE (BARC)

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The Plant Pathology & Pesticide Residue Section of the Nuclear Agriculture and Biotechnology Division, BARC, is engaged in various biochemical and ecological studies on different organochlorine, organophosphorous, carbamate, fungicide and herbicide groups of pesticides. Pesticide research involving radiotracer techniques for precise quantitative and qualitative analysis is conducted at this centre. The tracer technique is done to attain accurate data on dissipation rates of pesticides, interaction of pesticides with the environment and the metabolism of pesticides in field and laboratory conditions.

Objectives:

- Monitoring the fate and persistence of these chemicals in soil and water ecosystems under tropical climatic conditions.
- Bioremediation of pesticide residues in soil, water and sediments using radioactive, non-radioactive and genetic techniques.
- Monitoring pesticide residues in the environment and food commodities.
- Training researchers and students from all over the country on using radiolabelled compounds.
- Decontamination of pesticides from the environment.

Achievements:

- Fate of pentachlorophenol, pentachlorobenzene, toxaphene, isomers of HCH and carbaryl was studied in laboratory conditions using radiolabelled carbon in the pesticide moiety, and quantification of the volatilized, mineralized and bound fraction was done.
- Fate and persistence of DDT in Indian soils under different soil and temperature regimes was studied. The results showed different behaviour of pesticides at different soil temperatures and soil textures.
- Extensive studies to understand the interaction of pesticides with soil microbial activities responsible for soil fertility, showed that pesticides applied at normal recommended field levels do not have a deleterious effect.
- Effect of DDT residues on crop plants and its effect on cash crops like chilli and other vegetables was studied.
- Bioremediation of DDT in polluted soils by high potential hybrid strains of bacteria developed by genetic manipulation from low potential naturally occurring strains in soils.

Experts: *Dr. N.B.K. Murthy, Dr. J. Mitra, Dr. S.P. Kale, Dr. P.K. Mukherjee, Ms. Latha J, Mr. S.T. Mehetre.*

Significant Research Publications

1. Mitra J. and K. Raghu, 1998. *Detrimental effects of soil residues of DDT on chilies (Capsicum annum). Fresenius.* Environmental Bulletin. Vol. 7; 8 – 13.

Abstract: The effect of DDT residues on growth and yield of chilli was studied. A high-yielding and high capsicum containing variety of chilli was grown in the field containing black clay soil. It was observed that there was a significant reduction in growth and yield of chillies in treated areas. The detrimental effects of DDT could be attributed to the high oil content of this crop.

2. Mitra J. and K. Raghu, 1986. *Rice straw amendment and degradation of DDT in soils.* Toxicology and Environmental Chemistry. Vol. 11; 171 – 81.

Abstract: Presence of DDT was decreased by flooding and rice straw amendment with increased formation of DDD in several soil sample studied. The DDD formed decreased further over a period of time. Studies with radiolabelled DDT showed DDD as a major degradation product with DDE, DDOH, DBP, DDM and dicofol occurring at low amounts. Rice straw amendment decontaminated the DDT polluted soil to a considerable extent.

RAJASTHAN

JAIPUR

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The Rajasthan Agricultural University started pesticide research from 1984, when it was made one of the centres for the AICRP. The pesticide section at RAU works on monitoring, decontamination, and evaluating pesticides used in the state of Rajasthan.

Objectives:

- Monitoring of pesticide residues in soil, water, food commodities, vegetables, seeds and oil, milk, fruits, spices and fodder.
- Studying pesticide dissipation in crops.
- Determining waiting periods and tolerance limits of pesticides and recommening them to the state government for implementation of the limits.
- Pesticide decontamination studies.
- Development of cost – effective analytical techniques for the detection of a few groups of pesticides.

Achievements:

- Decontamination processes for vegetables were possible for a few pesticides.

Malathion residues from chillies were found to be below detectable limits even from the zero day samples, when washed properly. Cooking removed malathion residues from green chillies. Washing and cooking of brinjal reduced the waiting period of oxydemeton–methyl and endosulphan.

- A simple and quick method for the estimation of carbofuran residues in soils and plant samples developed. Carbofuran samples could be detected by chemical treatment and then measuring the O.D. or optical density.

Experts: *Dr. Alamelu Gupta, Head, Dr. Ashok Gupta, Dr. Banani Singh, Dr. M.S. Parihar.*

Significant Research Publications

1. Gupta A., B. Singh, N.S. Parihar and A. Bhatnagar, 1998. *Pesticide residues in farmgate samples of bottle gourd, cauliflower, cabbage and fengreek at Jaipur.* Pesticide Research Journal. Vol. 10 : No. 1 ; 86–90.

Abstract: The farmgate samples of bottle gourd(27), cauliflower(27), cabbage (13) and fenugreek(5), when monitored for possible pesticide residues, showed the presence of monocrotophos, fenvalerate, endosulphan, phosphamidon, HCH, DDVP, dimethoate, chlorpyriphos and methyl demeton. One sample of bottle gourd, nine samples of cauliflower, five samples of cabbage and two samples of fenugreek showed insecticide residues above maximum residue limit(MRL).

2. Gupta A., B. Singh, N.S. Parihar and V. Singh, 1998. *HCH and DDT residues in bovine milk and milk powder.* Pesticide Research Journal. Vol. 9 : No. 2 ; 235–37.

Abstract: Nine bovine milk samples and six popular brands of milk powder samples collected locally showed the presence of HCH residues. Five bovine milk samples showed beta–HCH isomer above maximum residue limit (MRL). No milk powder sample showed alpha and delta–HCH residues but one milk powder sample was found to contain beta and gamma–HCH residues above MRL. None of the samples contained DDT residues.

South India

ANDHRA PRADESH

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The Pesticide Residue Laboratory was established in the Andhra Pradesh Agricultural University, Hyderabad, in 1978. The unit has been involved with the AICRP on pesticide resudes from 1983 and to date it is working in this project with new parameters on pesticide research.

Objectives:

- To organize, promote and coordinate research on pesticide residues in agricultural and other components of the environment at an all-India level.
- To study the dissipation of pesticides in crops from supervised trials with recommended pesticides.
- To work out the safety periods of pesticides in crops.
- To monitor pesticide residues in abiotic and biotic components.
- To devise and improve sampling, extraction and analytical procedures in pesticide research.
- To carry out decontamination studies for removal of pesticides from food commodities.

Achievements:

The Pesticide Laboratory has monitored a variety of crops for pesticide residues, evaluated safe waiting periods and conducted pesticide dissipation studies. Pesticides have been monitored in pulses, sugarcane, mango, banana, grapes, cereals and oil-seeds. The laboratory also monitors pesticides in other food commodities like animal and poultry feed, fish, eggs, chicken, mushroom, dairy products and beverages like tea and coffee. Human samples include breast milk. Dissipation pattern of endosulphan, monocrotophos, carbaryl, triazophos, lindane, fenvalerate, carbendazim, ziram, chlorpyriphos, quinalphos, dicofol, mancozeb and cypermethrin in a variety of vegetables.

Experts: *Dr. T. Ramesh Babu, Dr. S. Rao, Mr. M.A. Sultan, Mr. K.N. Reddy.*

Significant Research Publications

1. Srinivas P., T. R. Babu, M.A. Sultan, D.D.R. Reddy and T.B. Gour, 1996. *Dissipation and decontamination of monocrotophos, fenvalerate and carbaryl in okra.* Indian Journal of Plant Protection. Vol. 24: Nos. 1& 2; 86–89.

Abstract: The field experiment laid out with okra to study dissipation and decontamination of three insecticides, viz., monocrotophos, carbaryl and fenvalerate, indicated that the dissipation by the seventh day was were found to be 100 per cent in fenvalerate. Monocrotophos residues on the 10th were found to be 2.29 ppm, which are above the MRL and hence considered to be highly persistent. The treatment of fruits with two per cent tamarind solution dip for five min. followed by tap water wash and steam cooking for 10 min. was found to remove the residues of monocrotophos, carbaryl and fenvalerate to an extent of 41 per cent, 81 per cent and 100 per cent.

2. Rao B. N., M.A. Sultan, K.N. Reddy, D.J. Reddy and T. R. Babu, 1998. *Investigation of pesticide residues in fish grown around paddy fields.* Journal of Research ANGRAU, Vol. 26: No. 1; 20–23.

Abstract: Investigations were carried out at the Regional Agricultural Research Station, Andhra Pradesh Agricultural University, Maruteru, on the accumulation of pesticide residues in fish and crustacean species grown around paddy fields during the 1991,92 and 93 cropping seasons. HCH residues recorded were above MRL 0.25 mg/kg in all six species, while quinalphos residues recorded were above MRL 0.25 mg/kg only in the Puntus species. Residues of HCH, DDT, aldrin, including dieldrin, recorded below in all the eight species collected during 1993. However, endosulphan residues recorded above MRL 0.2 mg/kg in prawns, viz. *Macrobrachium malcomsomii* and *M. rosenbergii.*

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Indian Institute of Chemical Technology has over 700 highly professional scientists and technicians with excellent laboratory instrument facilities for research work. More than 150 technologies developed by IICT scientists are now in commercial production. The major areas of research are agrochemicals, drugs, organic intermediates, oils and fats, organic coatings and polymer catalysis, coal, engineering and design.

Objectives:

- To provide globally competitive, environmentally friendly technologies in agrochemicals, drugs, organic intermediates, fine chemicals, lipids, science and technology.

- To achieve world–class expertise in frontier areas in organic synthesis, heterogeneous and homogenous catalysis and chemical processes, design, modelling and simulation.
- To build technical competence to offer science-based technical service the world over in relevant scientific areas.

Achievements:
Technologies available at IICT:

1. Agrochemical technologies: The off-shelf pilot-scale process for non-exclusive licensing include those for:

Monocrotophos
DDVP
Thiophanate
Acephate
Diazinon
Chlorpyriphos
Quinalphos
Butachlor
Biopesticides from neem and annona

2. Biocontrol Methods / Technologies for controlling pests
Pollution abatement through biotechnological approach and biocontrol of silkworm pests.

3. Development of new pesticides
Synthesization of a new organophosphorous pesticide of the phosphorothionate type and designated as RPR–II. This was found to be less toxic to non-target organisms but potent to insect pests.

Experts: *Dr. D.K. Iyengar, Deputy Director, Agrochemical Division, Dr. Kaiser Jamil Deputy Director, Biology & Biotechnology Division, Dr. P. Grover.*

Significant Research Publications

1. Rahman M. F., M.K.J. Siddiqui and K. Jamil, 1999. *Subchronic effect of neem based pesticide(vepacide) on acetylcholinestrase and ATPase in rat.* Journal of Environmental Science and Health, B., Vol. 34: No. 5; 873–884.

Abstract: Acetylcholinestrases, Sodium–Potassium, Magnesium and Calcium–dependent ATPases were monitored in rats' brains when treated orally with three different doses of Vepacide, an active ingredient from neem seed oil daily for 90 days. The three enzymes mentioned above were inhibited whereas the Magnesium – ATPase levels were enhanced in both the sexes. The relative sensitivities of these ATPases to Vepacide indicated that Calcium – ATPase being more sensitive than Sodium–Potassium–ATPases' in both sexes. It was found that the magnitude of the Calcium ATPase inhibited by this compound was higher than that of the brain acetylcholinestrases.

2. Rahman M. F., M.K.J. Siddiqui and K. Jamil, 1999. *Biochemical alterations induced by new phosphorothionate (RPR–II) in tissues of male and female rats*. Indian Journal of Experimental Biology. Vol. 37; 546–552.

Abstract: The Indian Institute of Chemical Technology has synthesized a new phosphorothionate and designated as RPR–II. This is an organophosphorous pesticide which was found to be less toxic to non–target organisms but potent to insect pests. A study was conducted to investigate the effect of RPR–II on membrane bound target enzymes. A repeated administration of RPR–II caused significant increase of a few specific enzymes (taken under consideration for the study) in the liver, kidney and serum. A significant decrease in the specific enzymes in the lung was observed. The female rats were more susceptible than males with regard to enzyme alterations due to RPR–II.

TIRUPATI

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The Department of Zoology started with pesticide research in the early 70s. The department covered a number of aspects on pesticide research, from monitoring of pesticides in different environmental components, development of diagnostic tools for simpler, cheaper and rapid detection of pesticides, to the effect of pesticides on growth and development of animals. The department is equipped with sophisticated instruments and has an infrastructure to conduct advanced research in the area of pesticide science.

Objectives:

- The unit lays emphasis on the development of portable, rapid, sensitive and inexpensive methods for detection of pesticides.
- Development of diagnostic tools to assess the impact of pesticide pollution on the physiological and biochemical process within non–target organisms.
- Multi–species approach initiated to assess the extent of pollution in water bodies in and around Tirupati.

Achievements:

- Development of TLC–Enzymatic methods for detection of pesticides. The pesticides parathion and paraxon were detected using TLC–ChE inhibition techniques. These methods have been made portable where micro–enzymatic methods and portable biosensor strips employ immobilized enzymes which specifi-

cally detect organophosphorous pesticides and heavy metals. The unit has developed portable biosensors for the detection of organophosphorous compounds using enzymes from molluscs, for example, from the heptopancreas of *Pila globosa*.

- The unit has monitored organochlorine and organophosphorous pesticides in paddy straw, cow dung, cows' milk and water from tanks, paddy fields, tannery wastes and sugar industry wastes.
- Lethal limits were determined using several aquatic non–target organisms for several pesticides, including sumithion, sevin, malathion, methylparathion, BHC etc.
- Research showed that exposure to pesticides, particularly sumithion, sevin, methylparathion, fenvalerate and BHC results in decrease in moulting, reduction in limb bud generation and reproductive potential of crabs and prawns.
- The unit monitored changes in the levels of metabolism at whole animal level and tissue and cellular level in non–target organisms during exposure to several pesticides.

Experts: *Prof. Dr. R. Ramamurthi, former Vice Chancellor of S.V. University, Prof. Dr. K.V. Rao, Head, Prof. Dr. N.V. Nanda Kumar, Dr. P.S. Reddy, Dr. A. Bhagyalakshmi, Dr. S.V. Reddy, Dr. A. Usha Rani.*

Significant Research Publications

1. Bhagyalakshmi A., S. V. Reddy, R. Ramamurthi and P.S. Reddy, 1995. *Studies on the effect of Hexachlorocyclohexane on the growth and silk qualities of silkworm, Bombyx mori L.* Chemistry and Ecology. 1–8.

Abstract: Toxicity of an organochlorine insecticide, hexachlorocyclohexane (HCH), on the alterations in the growth and silk qualities of silkworm, *Bombyx mori* L. were investigated. HCH yielded higher growth constants (K), indicating impairment of growth of silkworms and silkglands. The decrement in fibrion content is significant. HCH treatment also resulted in considerable reduction in the cocoon, pupal and shell weights, survival and emergence of pupae and number of eggs laid and deterioration in quality and quantity of silk thread.

2. Nanda Kumar N.V., S. Rajendrababu, S. Udaybhaskar and K.S. Swami, 1981. *Survey of pesticide residue analysis in paddy straw samples from some farms of Chittoor District of Andhra Pradesh.* Journal of Food Science and Technology. Vol. 18; 33–34.

Abstract: Organochlorine and organophosphorous pesticide residues were determined by gas liquid chromatography and colorimetry in dried paddy straw samples from 36 farms of Chittoor district, Andhra Pradesh, India. A few samples showed high amounts of the residues which warrant careful application of the pesticide residues during paddy cultivation.

KARNATAKA

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The Pesticide Residue Laboratory was started in the early 1970s by Dr. M.D. Awasthi. The objective of this centre was to minimize human exposure to pesticides as a result of contaminated food and vegetable crops. The Laboratory periodically analyzes food materials so as to establish the extent of pesticide residue contamination levels in the food chain for their proper management by decontamination to safe levels. Studies on the fate of pesticides in the soil are carried out to find out the build-up of pesticide residues, adsorption and degradation in order to overcome the problem of pesticide contamination.

Objectives:
- Monitoring of pesticides in farmgate samples like food crops, oilseeds, pulses, vegetables and fruits, dairy products, soil and water.
- Analyzing the fate and behaviour of pesticides in the soils, that is, dissipation, persistence, adsorption and metabolism.
- Evaluating post harvest waiting period for pesticides in crops.
- Educating farmers on the effects of pesticide spraying on the harvest.

Achievements:
The unit has developed a new and inexpensive ELISA technique to detect pesticides, which is otherwise extremely expensive. In addition, the centre develops and standardizes methods for the Bureau of Indian Standards. The centre has evaluated the waiting period for pesticides in a number of agricultural commodities.

Experts: *Dr. M.D. Awasthi, Dr. D. Sharma, Dr. S. Mohapatra, Mr. A. K. Ahuja.*

Significant Research Publications

1. Ahuja A.K., S. Mahapatra, D. Sharma and M.D. Awasthi, 1998. *Monitoring of vegetables for pesticide residue contamination at Harvest.* Proceedings of International symposium on pest management and horticultural crops, Bangalore, 243–46.

Abstract: Eight vegetables, viz. cauliflower, cabbage, tomato, brinjal, okra, French bean, field bean and cucumber were monitored for residues of HCH and its isomers, endosulphan, dimethoate, monocrotophos, quinalphos, fenvalerate, cypermethrin and one fungicide — carbendazim. Most of the samples showed HCH isomers, endosulphan, monocrotophos, dimethoate and carbendazim.

2. Sharma D., S. Mahapatra, A.K. Ahuja, and M.D. Awasthi, 1998. *Persistence pattern of triazophos and lindane residues on okra and brinjal.* Proceedings of International symposium on pest management and horticultural crops, Bangalore, 252–56.

Abstract: Persistence and dissipation of trazophos and lindane residues were studied on okra and brinjal following their schedules for pest control. Triazophos spray at 350 and 700 g a.i. / ha affected the build-up of 1.24 and 4.23 ppm on okra fruits, against 0.61 and 1.88ppm on brinjal, while that of lindane spray at 350 and 700 g a.i. /ha has resulted in 3.05 and 5.24 ppm residues on okra, as against 6.91 and 9.25 ppm on brinjal. The persistence and dissipation pattern of triazophos residues with respect to the prescribed MRL suggests waiting periods of seven to nine days on okra and seven to 10 days on brinjal, while that of lindane were five to seven days on okra and four to six days on brinjal fruits to avoid any possible health hazard.

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The Rallis Research Centre at Bangalore is a toxicology and epidemiology centre, employing over 250 qualified and experienced research scientists. The Centre conducts pesticide research in the following areas:

- Toxicology — conducts subacute, oral and inhalation studies, skin sensitization, neurotoxicity, fish toxicity and avian reproduction toxicity. The Ecotoxicology centre carries out research on fish LC_{50}, algae and daphnia, earthworms, insect predators, insect parasites and honey bees.
- Teratology and *in vivo* mutagenicity — The centre conducts teratological studies on rats and rabbits to evaluate the foetuses of these animals for external, internal tissues/organs and bone/skeletal system malformations, studies chromosomal aberration and dominant lethal tests in bacterial mammalian cell cultures, mutation in microbes and mammalian cell gene mutation assays.
- Analytical chemistry — equipped with state–of–the–art analytical instruments, the centre is able to test compound authentication, method development and validation, stability and homogeneity in solvents, physical and chemical properties, residue analysis and a few more tests.
- Environmental impact studies — the impact of synthetic chemicals on the environment, target and non–target organisms.

- Training centres for farmers, dealers, sales people and extension officers, covering the use of pesticides in agriculture, integrated pest management and pest resurgence.

MYSORE

CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE (CFTRI)

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Objectives:
- Mammalian safety evaluation.
- Pesticide bioassays using storage insects, silkworms and fish.
- Fumigation in the control of storage insects.
- Development of fumigation technology.
- Research on pesticide toxicology, pesticide detoxification mechanism.
- Research on aspects of biotechnology and bioengineering aspects.

Pesticide laboratories at CFTRI include the Food Protectants & Infestation Control Unit and the Food Standards and Analytical Control Laboratory.

Food Protectants & Infestation Control Unit
Dr. N.G.K. Karanth started the pesticide section in 1979 and has been instrumental in keeping it as CSIR's premier food technology laboratory. The unit has diversified in various disciplines of pesticide research and, as a result, has made an immense contribution on pesticide science as a whole.

Achievements:
- Research on microbial degradation of pesticides.
- Research on enzymes of pesticide degradation.
- Production of "Agrocure", a biological formulation to abate HCH residues in soil.
- Work on pesticide specific biosurfactant production by bacteria.
- Lab level production of biosurfactant and its use as a cleaning agent.
- Development of quick chemical detection methods for pesticides.
- Development of ELISA for pesticides.
- Study of pesticide metabolism in plants and bacteria.
- Identification of pesticide tolerant plants.

Food Standards and Analytical Control Laboratory
This unit analyses the persistence of different fumigants in food grains stored in storage godowns. A number of fumigants like aluminum phosphide, ethylene dibro-

mide, methyl bromide, hydrocyanic acid and a few more are used in controlling insect pests. The centre also analyses the various factors responsible for the persistence of different types of fumigants used in India.

Experts: *Dr. N.G.K. Karanth, Dr. P.G. Deo, Dr. N. Ramesha, Dr. S. Rajendran Dr. K.A.A. Appaiah, Dr. K.M. Appaiah.*

Significant Research Publications

1. Appaiah K.M., 1996. *Fumigants residues in food commodities in India. In: Surveillance, prevention and control of food contaminants*, Toteja, G.S., Diwakar, S. and Saxena, B.N. (eds.), Indian Council of Medical Research, pp. 39–47.

Abstract: The persistence of aluminum phosphide, ethylene dibromide, acetonitrile, methyl bromide, ethyl formate, ethylene dichloride, carbon tetrachloride, ethylene oxide, hydrocyanic acid, methyl iodide, DDVP and carbon disulphide depends on dosage, exposure period, load, moisture content in grains, temperature, fat and protein content in grains. Aluminum phosphide persisted for four days after airing, ethylene dibromide residues 5 to 8 ppm in 10 days after treatment. The various factors responsible for the persistence of different types of fumigants used in India are being researched.

2. Karanth N.G.K. and P.G. Deo, 1993. *Pesticide decontamination of soil, water and foods: an overview.* Journal of Ecotoxicology and Environmental Monitoring. Vol. 3 : No. 3; 161–176.

Abstract: For decontamination of pesticides from soil and water, inoculation of soil with natural bacterial isolates or genetically constructed bacterial strains are the recent trends. For the decontamination of pesticides from food commodities, use of some wash solutions has been suggested. These include methods like hot water, blanching, rinsing with weak acids and bases, washing with detergents and the use of biosurfactants.

DEFENCE FOOD RESEARCH LABORATORY (DFRL)

Defence Research & Development Organisation, Ministry of Defence

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The Defence Food Laboratory has very recently ventured into the area of pesticide research. The laboratory is in its developmental stages in terms of infrastructure and equipment. The pesticide laboratory is expected to cater to the needs of the country's defence personnel with context to pesticide contamination in food commodities.

Objectives:
The Defence Food Laboratory's main priority is to find solutions to provide pesticide–free foods to the troops.

- Development of simple testing kits for detecting a few selected fungicides and insecticide residues for field application by troops.
- Studies on pesticide residues in perishables like fruits, vegetables, tea and tender coconut water.

Experts: *Dr. S. Jayaraman, Project Coordinator.*

UNIVERSITY OF MYSORE

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The Department of Studies in Applied Botany & Biotechnology conducts research to prevent pathogen infestation and disease of seeds. The department investigates the use of various chemical and biological agents to prevent diseases on seeds like rice, maize, sorghum and millet.

Objectives:

- Investigates the use of fungicides to control seed pathogens.
- Investigates the use of various biological agents as future biopesticides for a variety of seedlings.
- Studies the use and effectiveness of systemic fungicides and biopesticides for seed treatment.
- Researches the mode of action and the ways in which pathogens attack seeds.
- Monitors the amounts of chemicals persisting at different concentrations after controlling the storage loss, i.e. persistence rate at which pesticide remains after controlling the pest.

Achievements:

- *Pseudomonas fluorescens*, *Trichoderma harzianum* and *Cheatomium globosum* were found to be potential biocontrol agents against grain mould caused by *Fusarium moniliforme* in sorghum seeds. Among the three biopesticides used, *Pseudomonas fluorescens* was the most effective one against *F. moniliforme*.

Experts: *Dr. H.S. Shetty, Prof. and Head of the Department, Dr. M. Krishnappa Dr. S. Umesha, Dr. S.M. Dharmesh, Dr. N.S. Raju, Dr. S.R. Niranjana Dr. G.R. Janardhana, Dr. H.S. Prakash.*

Significant Research Publications

1. Raju N.S., S.R. Niranjana, G.R. Janardhana, H.S. Prakash, H.S. Shetty and S.B.

Mathur, 1999. *Improvement of seed quality and field emergence of Fusarium moniliforme infected sorghum seeds using biological agents.* Journal of Science, Food and Agriculture. Vol. 79: *in print.*

Abstract: Five different cultivars of sorghum seeds infected with a varied degree of *Fusarium moniliforme* were treated with biocontrol agents like *Pseudomonas fluorescens*, *Trichoderma harzianum* and *Cheatomium globosum*. The treated seeds were evaluated for per cent reduction of *Fusarium moniliforme*, seed germination, vigour index and field emergence. It was found that the pure cultures of *P. fluorescens* were more effective in reducing the *F. moniliforme* infection followed by *T. harzianum* and *C. globosum* than the bavistin treated and untreated seeds.

KERALA

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The CIFT is an organization of the Indian Council of Agricultural Research. The toxicological studies include monitoring of pesticides and heavy metals in marine organisms. The unit stresses on monitoring levels of pesticides in marine animals, especially those meant for human consumption.

Research contribution in the field of pesticide science by CIFT:
CIFT periodically analyzes fish, prawns, oysters and mussels for pesticides, so as to verify if pesticide levels are within, above or below the FDA levels. Black pomfret, mackerel, seer, tuna, vala, farmed prawns, oysters and mussels are collected from the markets and analyzed for a wide range of organochlorine pesticides such as DDT and its metabolites like DDE and DDD, HCH isomers, heptachlor and its epoxide, endrin, aldrin and dieldrin. Although all samples showed these pesticides, none were above the tolerance levels suggested by the FDA, therefore do not pose a health hazard to humans. However, constant monitoring of our fishes will definitely give an idea whether the concentration of these pesticides have exceeded the permitted levels prescribed by different nations.

Expert: *K. Ravindran, Director.*

Significant Research Publications

1. Radakrishnan A.G. and P.D. Antony, 1989. *Pesticides residues in Marine Fish.* Fishery Technology. Vol. 26: No.1; 60–61.

Abstract: Pesticide residues in four marine fishes, black pomfret, mackerel, marine vala and tuna are reported. The highest concentration is found in black pomfret, followed by tuna, vala and mackerel. The contents of various pesticides present in fish under study are well below the limits prepared by FDA to cause any health hazard.

2. Radakrishnan A.G., 1994. *Organochlorine pesticide residues in farmed prawn (Panaeus monodon) oyster (Crassostrea madrasensis) and mussel (Perna viridis).* Presented in 'Nutrient and Bioactive substances in aquatic organism' symposium held in Cochin in 1994.

Abstract: Farmed prawns, oysters and mussels were screened for a wide spectrum of organochlorine pesticides. Among the samples, mussels have a higher level of pesticides compared to prawns and oysters. In prawns, endrin levels were the highest, while in oysters the o'p,–DDT were highest among the different types of pesticides analyzed. However, the levels are below the toxicity limits permitted by different countries.

THIRUVANANTHAPURAM

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Pesticide research in Kerala Agriculture University was initiated in 1975. Initial pesticide research was on pesticide uptake, translocation, metabolism and persistence of the major pesticides used in the state. After 1986, when the Department of Entomology, KAU, became one of the centres for AICRP, the spectrum of pesticide research enhanced substantially. The department now has an infrastructure and expertise to conduct research on different aspects of pesticide toxicology. Presently, the Pesticide Research Unit covers monitoring of pesticides in food commodities, bioaccumulation of pesticides, effect of pesticides on fauna and flora and dissipation of pesticides.

Objectives:

- Quantification of waiting periods of insecticides in vegetables and spices.
- Monitoring of dissipation patterns of various recommended insecticides in vegetable crops.
- Study of persistence and metabolism of organophosphorous pesticides on different soil types and its impact on wildlife.

- Development of strategies to minimize pesticide residues in food commodities in Kerala.
- Study of the effect of pesticides in target and non-target organisms.
- Monitoring of pesticide residues in vegetables, dairy products, animal feed, oils, fish, drinking water, total human diet, infant formula and breast milk.

Achievements:

- Evaluated waiting periods of pesticides for common vegetables, viz. okra, brinjal, snakegourd, bittergourd, chillies and tomato.
- Evaluated waiting periods for spices, viz. pepper and cardamom. The waiting period of monocrotophos, quinalphos and mancozeb was found to be 30 days. The waiting period of quinalphos for cardamom is recommended by the Central Insecticide Board.
- Monitored pesticide residues in 400 samples of vegetables collected from markets and farmers from Kerala. None of the samples were free from pesticides. Samples of cowpea and bittergourd had the highest level of pesticide residues. Further, more than 30 per cent analysed vegetables were contaminated with one or more organophosphorous insecticides above MRL. This report was made for the first time in the state of Kerala.

Experts: *Dr. S. Naseema Beevi, Dr. T. B. Mathew, Dr. T. George, Dr. Anitha.*

Significant Research Publications

1. George T. and N.P. Agnihotri, 1999. *Enhanced biodegradation of recalcitrant pesticides in soil.* Pestology, Feb 1999, 224.

Abstract: An experiment was conducted to study the degradation of various recalcitrant isomers of HCH in soil by inoculating the soil with a gram negative, non–spore–forming mesophilic and aerobic bacteria *Sphingomonas paucimobilis*. Thus, it could be concluded that of the four HCH isomers, the bacteria preferentially degrade alpha and gamma isomers for meeting its energy needs while the beta and delta isomers are degraded only in the presence of other carbon sources or in combination with alpha and gamma HCH isomers by dehalogenase enzyme activity.

2. Beevi S.N., T. B. Mathew, A. Visalakshi, P.A.R. Ansari and D. Dale, 1996. *Organochlorine insecticide residues in milk and milk powder.* In: Surveillance, Prevention and Control of Food Contaminants: Proceedings of National Symposium organised by the Indian Council of Medical Research. G.S. Toteja, S. Diwakar and B.N. Saxena, (Eds.) pp. 24–29.

Abstract: As a part of monitoring of organochlorine insecticides in milk and milk powder, it was observed that samples collected from Trivandrum, Kerala, were contaminated with four isomers of HCH. The beta isomer of HCH was found to be the highest among the various HCH isomers. Samples collected from three milk producers co–operative societies were found to be contaminated with DDT.

PONDICHERRY

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The School of Life Sciences has been doing research in various areas, including environmental endocrinology. The department is being funded by agencies such as the Population Council, New York, USA, and the Indian Council of Medical Research.

Objectives:

- Evaluating the endocrine aspects of toxic compounds.
- Studing and documenting the effects of a few commonly used pesticides, like endosulphan, lindane and methoxychlor on reproduction in rats.
- The toxicological effect of different drugs on reproduction is under investigation.

Achievements:
The School of Life Sciences have documented that endosulphan causes an inhibitory effect in the reproductive organ weights and testicular steroidogenesis of immature rats.

Experts: *Prof. Dr. P. P. Mathur, Dr. C. Latchoumycandane, Ms K.C. Chitra.*

Significant Research Publications

1. Chitra K.C., C. Latchoumycandane and P. P. Mathur, 1999. *Chronic effect of endosulphan on the testicular functions of rat.* Asian Journal of Andrology. Vol. 1: No. 4;1–4.

Abstract: In endosulphan–treated rats, there was a reduction in the body weight and the weights of testes and accessory sex organs and a reduction in steroidegenesis.

VECTOR CONTROL RESEARCH CENTRE (VCRC)

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The Vector Control Research Centre is engaged in researching the problem of resistance in vector mosquitoes to insecticides, as well as operational research for the control of vector–borne diseases, particularly filariasis and malaria. Susceptibility status to conventional insecticides like DDT, BHC, malathion, etc., was monitored in vector mosquitoes collected from Tamil Nadu, Andhra Pradesh and Karnataka.

Objectives:

- Susceptibility–status monitoring of resistance to vector mosquitoes.
- Studies carried out to examine development of resistance in *Culex quinquefasciatus, Anopheles stephensi* and *Aedes aegypti* to allethrins that are used in mosquito mat and coil impregnation.

Achievements:

- An ICMR cell on monitoring and management of insecticide resistance has been established. The toxicological effect of different drugs on reproduction is under investigation.
- The susceptibility status to conventional insecticides like DDT, BHC, malathion, etc., was monitored in the states of Andhra Pradesh, Tamil Nadu and Karnataka. In Rameswaram, Tamil Nadu, *Anopheles culcifacies*, the vector of malaria, was found to be susceptible to malathion but resistant to DDT.
- Research conducted on insecticide resistance in the institute revealed malathion resistance in *Culex quinquefasciatus* was found inherited through autosomal incompletely dominant gene. Development and reversal of fenthion and malathion resistance in *Culex quinquefasciatus* over a period of four years showed that malathion resistance was complete in the field population. In the laboratory population, the resistant homogeneous strain ranged between 66 per cent and 68 per cent. Heterozygous gene for resistance was absent. Further, continuous exposure of *Culex quinquefasciatus* to fenthion affected its egg fertility and fecundity.
- Selection of *Anopheles stephansi* by permethrin resulted in the development of resistance in the F5 generation to a 13–fold increase to permethrin and cross resistance to a tune of seven, 10 and nine fold increase to cypermethrin, deltamethrin and alphamethrin, respectively.
- In view of the prolonged use of DDT and BHC for indoor application from 1958 to 1972 in Malkangiri, Orissa, the susceptibility status of the malaria vectors, *Anopheles stephensi* and *Anopheles fluviatilis* to these insecticides was monitored. The former species was resistant to DDT, BHC and malathions while the latter was resistant to BHC but susceptible to DDT. This is first report of resistance in *Anopheles fluviatilis* to BHC.

Experts: *Dr. P. K. Das, Director, Dr. K.N. Panicker, Dr. S.S. Sahu, Dr. K.P. Patra Dr. T. Mariappan, Dr. C.B.S. Reddy.*

Significant Research Publications

1. Sahu S.S. and K.P. Patra, 1995. *A study on the insecticide resistance in Anopheles fluviatilis and Anopheles culcifacies to BHC and DDT in the Malkangiri district of Orissa.* Indian Journal of Malariology. Vol. 32; 112–18.

Abstract: The susceptibility status of malaria vectors to HCH and DDT was studied in Malkangiri district, which has been highly endemic for malaria for many decades. *Anopheles fluviatilis* is the major malaria vector and *Anopheles culcifacies* is a secondary vector in the area. HCH is being used in malaria control programmes from 1972 onwards, while before that DDT was being used. The study reports that *Anopheles fluviatilis* has developed resistance to HCH and is susceptible to DDT. *Anopheles culcifacies* was found to be resistant to both the insecticides. Extensive use of pesticides in agriculture and indoor residual spraying of HCH for malaria control might have led to the development of resistance in these malaria vectors.

2. Das P.K. and P.K. Rajagopalan, 1980. *Insecticide susceptibility status of colonized strain of Anopheles culcifacies.* Indian Journal of Medical Research. Vol. 72; 218–21.

Abstract: Susceptibility of *A. culcifacies* larvae to DDT, HCH, temephos, fenthion, malathion and DDVP and adult mosquitoes to DDT, dieldrin, malathion, fenthion, fenitrothion and propoxur were tested. Larvae of this species were found susceptible to all the insecticides tested, whereas adults were resistant to DDT but susceptible to other insecticides. The implications of these findings in the control programme is discussed.

KARAIKAL

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Pandit Jawaharlal Nehru College of Agriculture was established in 1987. The pesticide section focus on the effect of the use of different pesticides on the rice crop, as it is the staple diet in south India. In addition, the pesticide section monitors pesticides in different food commodities.

Objectives:

- To study the efficacy of different pesticides against the major pests of rice and their effects on the natural enemies occurring in the ecosystem.
- Dissipation of pesticides from soil.
- Use of neem products and their effect on potential predators.
- To assess host–plant resistance.
- Monitoring pesticide residues in food commodities.
- Influence of pesticides on soil microbes.

Achievements:

- The effectiveness of indigenous plant products against pests of okra (lady's fingers).
- Efficacy of pesticides against sucking pests of cotton and botanicals against rice leaf hopper.
- Safety of neem against *Trichogramma chilonis*.
- Influence of carbofuron on soil microbes.

Experts: *Dr. S. Letchoumanae, Prof. and Head, Dr. D. Adiroubane, Dr. K. Kumar.*

Significant Research Publications

1. Adiroubane D. and S. Letchoumanae, 1998. *Field efficacy of botanical extracts for controlling major insects pests of Okra (Abelmoschus esculentus)*. Indian Journal of Agricultural Sciences. Vol. 68: No. 3; 168–170.

Abstract: A field experiment was conducted during 1994 to evaluate efficacy of three plant extracts and synthetic insecticides endosulphan and carbaryl and their combination products in controlling okra jassids and fruit borers. All treatments suppressed both the jassid population and fruit borer incidence.

2. Adiroubane D. and S. Letchoumanae, 1996. HCH and DDT residues in bovine milk samples from Karaikal region in U.T. of Pondicherry. Pesticide Research Journal, Vol. 8: No. 2; 115–18.

Abstract: Twenty one bovine milk samples from milk collection centres of Karaikal Milk Supply Co-operative Union have been evaluated for DDT and HCH residues. All the 21 samples were contaminated with HCH residues above MRL while only five samples showed DDT above the MRL.

TAMIL NADU

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The Centre for Advanced Study in Marine Biology is actively engaged in teaching, research and extension activities. The centre has completed 60 research projects funded by national agencies such as DOD (Department of Ocean Development), UGC (University Grants Commission), DST (Department of Science and Technology), CSIR (Council of Scientific & Industrial Research), ICMR (Indian Council of Medical Research), MoE&F (Ministry of Environment & Forests), DAE (Department of Atomic Energy), ONGC (Oil & Natural Gas Commission) and international agencies like

DANIDA, ONR USA, IFS Stockholm, Sweden and TNSCS & T, WWF for Nature–USA, and a few collaborative projects from Japan.

Objectives:
The centre focuses on diverse issues related to pesticide pollution, like:

- Chemical oceanography, including pollution. Organochlorine pesticides like DDT and HCH in different trophic levels from the Vellar river watershed, southern India and the Bay of Bengal are monitored to assess the level of pesticidal pollution in the various trophic levels. The Gulf of Mannar is monitored for DDT and HCH residues. The centre monitors periodically the levels of persistent pesticides in mammals in marine and fresh water ecosystems.
- Organochlorine pesticide residues in foodstuffs from India.

Achievements:

- Monitored organochlorine residues in marine and river dolphins in India.
- Quantification of pesticides in aquatic fauna and organochlorine in the commercially important fishes of the east coast of India.
- Recent trends of the pesticide consumption and pollution in India.
- Pesticides in the resident and the migratory fauna of south India.
- Fate of pesticides in the tropical environment.
- Use of organochlorine as chemical tracers in determining some reproductive parameters of Dall's porpoises.
- Seasonal variation of organochlorine insecticides in air from Porto Novo, south India.
- Persistent organochlorine residues in paddy and upland soils of south India.
- Specific pattern of persistent organochlorine residues in human breast milk from south India.
- Persistent organochlorine residues in foodstuffs from India and their implications on human dietary exposure.

Expert: *Prof. Dr. A.N. Subramanian, Head*

Significant Research Publications

1. Kannan K., S. Tanabe, A. Ramesh, A. Subramanian and R. Tatsukawa, 1992. *Persistent organochlorine residues in foodstuffs from India and their implications on human dietary exposure*. Journal of Agriculture and Food Chemistry.Vol. 40; 518–524.

Abstract: Foodstuffs collected from different regions in India were analyzed for the presence of DDT, HCH, HCB, aldrin, dieldrin, heptachlor and PCBs. Concentration of these compounds in a few dairy products were above maximum residue limits set by FAO/WHO as well as the Ministry of Health of the Indian Government.

COIMBATORE

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SACON has been focusing its attention on biodiversity conservation. The centre has various divisions like Avian Ecology, Conservation Biology, Wetland Ecology, Terrestrial Ecology, Environmental Impact Assessment and Ecotoxicology, addressing various conservation needs of the country. SACON is an autonomous organization, aided by and under the Ministry of Environment and Forests, Government of India.

The Ecotoxicology Unit:
The unit is presently involved in a project entitled 'Pesticide Contamination in the district Nilgiris' where the impact of certain pesticides on a few species of fish–eating and insectivorous birds in the Niligiris is being researched.

Experts: *Dr. S. Murlidharan, Dr. S.M. Murugavel.*

Significant Research Publications

1. Muralidharan S. and S.M. Murugavel. *Levels of organochlorines in select ecological components in Nilgiri district.* Proceedings of the Seminar on Research Findings in the Field of Wildlife, Habitat and Biotic pressure in Nilgiri Biosphere Reserve. Tamil Nadu Forest Department, Mudamalai, 6–7 March, 1998 (in press).

Abstract: In the Nilgiri district roughly 40 to 50 types of pesticides are used and many do not figure in the official list. The changes in the pesticide consumption pattern is directly related to the cropping pattern. Approximately 600 metric tonnes of pesticides in the form of granules and 28,000 litres in the form of liquids are used every year. However, there has been a steep increase in the emulsified liquid pesticides and a decrease in the use of granular pesticides. Reservoirs such as Avalanche, Emerald, Kamraj Sagar, Pykara, Upper Bhavani and Moyar–Maravakandy, lakes such as Ooty lake and rivers such as Coonoor and Moyar were samples for pesticide residues. Six species of fishes, namely, Scale Carp, Leather Carp, Mirror Carp, Rainbow Trout, Cichlids, *Barbus carmuca,* and birds like Little Green Heron, Pond Heron and Little Erget were tested for pesticide residues. Results showed DDT and its metabolites like DDE and DDD, isomers of HCH (alpha, beta and gamma) and isomer alpha and beta Endosulphan in water, sediments, fishes and birds.

2. Muralidharan S., 1998. *Organochlorine residues in eggs: impact on bird population.* In Proceedings of the Training Course on Insecticide Toxicology, Tamil Nadu Agricultural University, Coimbatore, 4–18 November.

Abstract: The paper deals with the methodology for estimation of organochlorine pesticide residues in eggs, procedure for egg–shell evaluation and known instances of impact on bird population. The paper emphasises the need for monitoring the residue levels in eggs and their impact on birds.

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The Pesticide Toxicology Research Unit was initiated in 1972 by Dr. A. Regupathy with the financial support from the University and Small Scale Pesticide Formulators. It is a part of the Department of Entomology. It has been recognised as one of the centres of pesticide research by ICAR, ICMR, BARC, NCL and Spices Board.

Objectives:

- Monitoring of pesticides in food commodities in the environment.
- Microbial degradation of pesticides.
- Monitoring and management of insecticide resistance.
- Assessing the bioefficacy of new formulations in laboratory and field.
- Formulation and residue analysis of pesticides.
- Estimating safe waiting period for different pesticides in different crops.
- Studying the effect of pesticides on beneficial and non–target organisms.
- Training on safe handling and proper use of pesticides.
- Imparting education on pesticide toxicology at post graduate level.

Achievements:

- TNAU has monitored pesticides in cows' milk, human milk, eggs, animal feeds and vegetables since 1989. It has developed protocols for pesticide residue analysis.
- The unit has developed new formulations in plant–based pesticides like neem, worked out waiting periods for various pesticides in field and horticultural crops since 1970, evaluated bioefficacy of pesticides against field and horticultural crop pests.
- In addition, it has developed an insecticide monitoring kit for *Helicoverfa armigera.*
- Presently, the institute is involved in a number of research assignments like pesticide dissipation studies, plant–based pesticides and evaluation of the dietary intake of pesticides and health effects of pesticides among the staff at pesticide retail units at Tamil Nadu, occupational health hazards among the manufactures, loaders, mixers and sprayers.

Experts: *Dr. T. Manoharan, Dr. R. Jayakumar, Dr. S. Chandrasekaran, Dr. S. Kuttalam, Dr. C. Chinniah, Dr. K. Gunasekaran.*

Significant Research Publications

1. Chandrasekaran. S., S. Kuttalam and A. Regupathy, 1997. *Investigation on the level of contamination of insecticide residues in ready to market vegetables in Tamil Nadu.* Vegetable Science. Vol. 24: No. 2; 136–39.

Abstract: Eighty-five farmgate samples of seasonal vegetables, namely brinjal(30), okra(30), cabbage(15) and cauliflower(10) were monitored for pesticide contamination of residues of thirteen insecticides applied during their crop growth period for pest management. Among the samples monitored, three of brinjal, four of cabbage, two of cauliflower were free from pesticide contamination. Out of the thirty brinjal samples analyzed, three with fenvalerate and one with endosulphan were exceeding the MRL of 0.2 and 2.0 mg/kg, respectively. Two samples out of the fifteen cabbage analyzed were over and above the MRL for cypermethrin(0.5 mg/kg). Four cauliflower samples exceeded the MRL out of the ten monitored with cypermethrin(2), fenvalerate(1) and monocrotophos(1).

2. Chandrasekaran S. and A. Regupathy, 1998. *Survey on pesticide storage pattern in the retail outlets and status of occupants' health in Tamil Nadu.* Pesticide Research Journal. Vol. 10: No. 1; 80–85.

Abstract: The general layout of the retail unit consisted of a room partitioned in the middle to separate the sale point and storage. More than 85 per cent of the retail outlets were provided with ceiling fans, 65 per cent with windows and 25.9 per cent with exhaust fans. The most frequent adverse effects expressed by workers with pesticides, irrespective of the cadre, were headache (23.86 per cent), dizziness (18.8 per cent), cough (10.23 per cent), skin irritation (7.95 per cent), eye irritation (7.95 per cent), nausea (5.68 per cent). The other adverse effects were below the level of 5.6 per cent.

MADURAI

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The Department of Molecular Microbiology is working on biopesticides. *Bacillus thuringiensis* (Bt) is an important industrial microbe as it has the ability to produce proteinaceous, insecticidal, parasporial inclusion generally during sporulation. The insecticidal crystal proteins referred to as cry proteins get converted into toxins once it enters the insect larval digestive system, resulting in larval death. Unfortunately, the cry proteins are very unstable in the environment and expression of the cry genes is very poor in unrelated plant hosts. The scientists at the School of Biotechnology are evolving methods for the cry genes to get expressed in plants so that the insect pests can no longer grow and develop in their host plants.

Objectives:
The Department has been concentrating on four major aspects of the biology of *Bacillus thuringiensis* (Bt):

- Establishing the molecular basis for poor expression of cry genes in plants;
- Improving the field persistence of the *cry* proteins;
- Understanding the mechanism(s) related to the unique regulation of the expression of *cry* gene of specific strain;
- Expressing the *cry* genes in the chloroplasts of crop plants.

Experts: *Prof. V. Sekar, Head, R. Jaya Kumar, S.N. Sudha, G. Srinivas S.J. Vennison, P. Balasubramanian.*

Significant Research Publications

1. Naidu M. M. and V. Sekar, 1995. *Possible use of Bacillus thuringiensis in coffee biotechnology.* Journal of Coffee Research. Vol. 25: No. 2; 106–10.

Abstract: Coffee is one of the leading commodities in international trade and the world's most important agricultural export product. The berry borer is the most serious pest of coffee all over the world. The berry borer was first observed in 1990 in a few coffee plantations in Gudalur in Tamil Nadu. The Coffee Board an evolved an integrated pest management schedule. Still, the pest is rapidly spreading to newer areas. Biotechnology has emerged as one of the promising branches in controlling this pest in coffee plantations. Genetic engineering offers an important contribution to coffee plantations and one of the possible applications is the use of Bt. genes for insect pest management.

2. Sudha S.N., R. Jayakumar and V. Sekar, 1999. *Introduction and the expression of the cryIAc gene of Bacillus thuringiensis in a cereal–associated bacterium, Bacillus polymyxa.* Current Microbiology. Vol. 38: 163–67.

Abstract: The abilities of *Bacillus polymyxa and Bacillus thuringiensis* to survive in rice phyllosphere were compared; it was found that *B. polymyxa* colonizes the crop better. Efforts were made to introduce the *cryIAc* gene of *Bacillus thuringiensis* into *B. polymyxa* strains, so that the application of such transgenic *B. polymyxa* would prove to be dually beneficial to rice crops both as biopesticide and as a biofertilizer. Immunoblot analysis of the recombinant organism containing *cryIAc* gene indicated efficient expression of this gene in the host. Bioassays of the first instar larvae of the yellow stem borer of rice revealed that the protein preparations were toxic.

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The Toxicology Unit in the Department of Entomology at the Agricultural College and Research Institute is a new centre for toxicological research.

Objectives:

- Testing of new insecticide/herbicide/fungicide molecules for their bioefficacy/ residues for the purpose of registration.
- Standardization of residue estimation protocol for new pesticide molecules.
- Insecticide resistance monitoring by generating areawise susceptibility data for major crop pests.
- Development and formulation of botanical insecticides.
- Pesticide formulation — quality control.
- Development of insecticide application technology.
- Management of stored product pests involving insecticides/ plant products.
- Development of insecticide–based integrated pest management (IPM) and insecticide resistance management (IRM) tactics for the major crop pests.

Achievements:

- The unit's scientists have developed a resistance monitoring kit for the field level monitoring of insecticide resistance in *Helicoverpa armigera* (a pest of a wide variety of crops such as cotton, groundnut, sunflower and pigeon pea) and *Plutella xylostella* (pest of vegetables like cabbage, cauliflower, turnip, beetroot and mustard).
- A few discriminative doses have been elucidated for a few insect pests for the purpose of insecticide resistance management. A stable neem formulation was developed and this technology was made available to industries.

Experts: *Prof. A. Regupathy. Dean and Head of the Unit, Dr. K. Chozhan, Dr. G. Ravi.*

Significant Research Publications

1. Regupathy A., 1994. *Problems and prospects of management of insecticide resistance in Helicoverpa armigera (Hubner) in India*. In: Challenging the Future: Proceedings of the World Cotton Research Conference–1, Brisbane, Australia. G.A. Constable and N.W. Forester (Eds.), pp. 556–562.

Abstract: Insecticide resistance in *Helicoverpa* (Hubner) is a major threat to crop production in India. Critical gaps in the knowledge base management of resistance of *Helicoverpa armigera* in India are identified. The status, need and constraints to utilization of insecticide resistance management (IRM) technologies such as scouting, resistance monitoring, temporal and spatial restrictions on the use of pesticides, regulation of application rate, application technology and use of biocontrol agents are discussed in relation to conditions prevailing in India. A simple IRM strategy of improved control of this devastating pest is suggested. The need for integrated pest management (IPM) in other hosts *H. armigera* crops is emphasized.

2. Regupathy A., 1994. *Pesticide residues in plantation and spice crops*. In: Advances in Horticulture. Vol. 10 — Plantation and Spice Crops, Part 2. K.L.Chadha and P. Rethinam (Eds), Malhotra Publishing House, New Delhi, pp. 1177–184.

Abstract: The plantation and spice crops mostly being perennial have complex pest and disease problems which cannot be solved by simple management techniques. The pesticides used in India against insect, mite and nematode pests are highly broad spectrum. Most of the pesticides used actually miss the target and enter soil and

aquatic environments. Hence, on one side, a wide range of non–target organisms, including human beings and domestic animals, are exposed to these pesticides, and on the other side, the residue in the produce may affect the export earnings. Information on the form and the quantity of pesticide residues in the plantation ecosystem is essential to assess health effects and to develop abatement technology.

3. Gowri T. and A. Regupathy, 1996. *Multiresidue analysis of insecticides in spices by GC–ECD.* Journal of Plantation Crops. Vol. 2 (supplement); 745–757.

Abstract: Multiresidue analysis of spice matrix fortified with insecticides was tested for their recovery using five different methods. The recovery varied in different methods. Among the various extraction solvents, aqueous acetonitrile gave recovery of all insecticides. Florosil column gave the highest recovery compared to alumina or silica gel. The procedures are discussed and further improvements suggested for organophosphorous and chlorinated hydrocarbons.

PADAPPAI (KANCHEEPURAM DISTRICT)

FREDRICK INSTITUTE OF PLANT PROTECTION AND TOXICOLOGY (FIPPAT)
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FIPPAT is an autonomous independent research organization involved in the evaluation of pesticides and related compounds. Various parameters on efficacy, toxicology and residual aspects are being generated for the purpose of registration of pesticides in India and abroad.

Objectives:
- Development of analytical methods for the quantification of pesticides and their metabolites in various matrices such as soil, water, plant, air, food and biological substrates.
- Validation of methods developed for pesticide analyses.
- Analysis of various solids, liquid–and aerosol–based pesticides and related compounds for their environmental fate.
- Data generation on complete chemistry aspects for the registration of pesticides.
- Designing quality control procedures/protocols/master schedules.
- Decontamination of chlorinated pesticides from water at trace levels.
- Develop methods for evaluation of various insecticides, herbicides, fungicides and botanicals.
- Evaluation of residues at the dietary intake and dietary exposure studies (animal tissue and fat).

Experts: *Dr. Balasubramanian, Dr. A. Ramesh.*

Significant Research Publications
1. Ramesh A., 1999. *Pesticide formulation — Recent development and their applications in developing countries.* Pesticide Information: Vol. xxiv; No. 4; 24–25.

East India

ASSAM

JORHAT

ASSAM AGRICULTURAL UNIVERSITY (AAU)

Department of Entomology
AICRP on Pesticide Residues
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The Assam Agricultural University started research on pesticide residues after it was selected as one of the centres for the AICRP in 1983. The pesticide unit conducts dissipation studies for various pesticides applied in the field, monitors residues of pesticides in food commodities and devises methods to minimize pesticide residues in food products.

Objectives:

- Dissipation of pesticides in crops through supervised trials and evaluation of waiting periods.
- Monitoring pesticide residues in the food and environmental components.
- Studying the effect of processing of food on minimizing the levels of pesticides.

Achievements:

- Supervised trials on rice, maize, potato, brinjal, cowpea, okra, tomato, betel vine, cabbage and ridgegourd were conducted and the safe waiting periods were evaluated for different recommended pesticides.
- Monitoring of pesticide residues in vegetables, milk, eggs, animal feed, water and soil.

Experts: *Dr. A.N. Mukhopadhyay, Head of AAU, Vice Chancellor, Dr. D.N. Dutta, Principal Investigator and Dean, Faculty of Agriculture, Dr. B. Borah, Principal Scientist, AICRP on Pesticide Residues, Dr. M.M Goswami, Dr. K.C. Deka,Dr. D. Bhattacharyya.*

Significant Research Publications

1. Deka K.C. and M.M. Goswami, 1997. *DDT and HCH residues in market samples of certain milk products and eggs in and around Jorhat.* Journal of Agriculture, Science and Society of North East India. Vol. 10 : No. 2; 211–16.

Abstract: Samples of ghee, cream, curd and eggs were collected from markets in and around Jorhat and analysed to assess the extent of contamination with DDT and HCH residues. None of the samples carried residues in excess of the respective permitted limits.

2. Goswami M.M. and D.N. Dutta, 1994. *Residues of Carbofuran in Potato and Brinjal. Journal of Applied Zoology Research.* Vol. 5 : No. 1; 75–76.

Abstract: Potato and brinjal crops were treated with carbofuran and the levels of the residues present in different time intervals were recorded. A maximum residue of 0.687 ppm was found on the fifth day after the third application, which required about 22 days to reach the maximum residue limit of 0.2 ppm.

REGIONAL RESEARCH LABORATORY

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— inform @ csir.res.in

The Regional Research Laboratory, Jorhat, an organization of the Council of Scientific and Industrial Research, started functioning from 1961.

Objectives:

Pesticide research at RRL, Jorhat, started in 1976 with the following aim:

- Process development of indigenous technology of known pesticides.
- Import substitution.
- Technology development of a few organophosphorus pesticides like phosphamidon, quinalphos and chlorfenvinphos.

Achievements:

- Technology development of following pesticides at bench scale level include fenthion, glyphosate, acephate, methamidophos and metham sodium.
- The technology which it developed was marketed to industries. For instance, phosphamidon was transferred to Sudarshan Chemical Industries Limited, Pune; National Organic Chemicals Industries Limited, Mumbai and Voltas Limited, Andhra Pradesh. Quinalphos was transferred to Sudarshan Chemical Industries Limited. Chlorfenvinphos was transferred to National Organic Chemicals Industries Limited, Mumbai.

Experts: *Dr. A. Goswami, Dr. M. Goswami, Dr. R.C. Rastogi, Dr. R. C. Borthakur Dr. N. Borthakur, Dr. R.P. Sharamah, P.R. Bhattacharyya, Dr. N.C. Baruah Dr. J.N. Baruah, Dr. P. Baruah.*

Significant Research Publications

1. Borthakur R.C., A. Goswami, M. Goswami, N. Borthakur, R.C. Rastogi and P.R. Bhattacharyya, 1986. *Synthesis and insecticidal activity of some new phospho-*

rodithionate esters of substituted acetophones. Indian Journal of Chemistry. Vol. 25B; 668.

2. Borthakur N., A. Goswami and R.C. Rastogi, 1991. *Convenient syntheses of N–Acetyl Phosphoramidothioates*. Chemistry and Industry, 353.

ORISSA

BHUBANESWAR

ORISSA AGRICULTURAL UNIVERSITY (OUAT)

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The Orissa Agricultural University and Technology initiated pesticide research since April 1984, when it was selected as one of the centres for the AICRP. The pesticide section at OUAT has contributed to various aspects of pesticide research. These include monitoring, decontamination, quality assurance programmes, and work on persistance of pesticides and soil–pesticide interaction.

Objectives:

- Evaluate the extent of pesticide contamination in market and farmers' field vegetables, pulses, cereal, cattle feed, milk and milk products, fish and other food commodities.
- Evaluate safe waiting period for cereals, pulses and vegetables crops by supervised trials.
- Effectiveness of various simple kitchen methods tested to minimize pesticide residues in vegetables.
- Test the quality of surface and groundwater for pesticidal contamination. Pesticide contamination studies to assess different types of diets.
- Study the adsorption, distribution and leaching loss of carbofuran in different soil columns of black, laterite and alluvial soils of Orissa.
- Study the persistence of pesticides in soil and crops, and the influence of different amendments on the process of degradation of pesticides.

Achievements:

- Decontamination process for vegetables was possible for a few pesticides. Washing twice with 1 per cent solution of alcohol or with 0.5 per cent solution with baking soda (1/2 teaspoon of baking soda with 1/2 litre of water) could remove more than 70 per cent of residues of quinalphos or endosulphan from cauliflower. One percent solution of common salt or vinegar could remove

almost 60 per cent of pesticide residues from vegetables.

- Leaching losses, movement and distribution of carbofuran indicated leaching was more in coarse–textured laterite soil as compared to fine–textured alluvial and black soil.
- Studies on residues of quinalphos in rice indicate there were 15.9 days and 17.5 days for lower (0.05 per cent) and higher (0.1 per cent) dose of application of peptides, respectively.

Experts: *Dr. H.K. Senapati, Head of the unit, Dr. A.K. Pal, Dr. M.R. Pattnaik, Dr. N. Swain, Dr. S.K. Mohanty, Dr. A. Acharya,Dr. P. Samant, Dr. G. N. Mitra, Dr. D. Sahu.*

Significant Research Publications

1. Samant P., H.K. Senapati, A.K. Pal, M.R. Pattnaik and N. Swain, 1997. *Persistence of chlorpyrifos in greengram and blackgram.* Pesticide Research Journal. Vol. 9 : No. 2 ; 261.

Abstract: A field experiment was conducted on persistence of chlorpyrifos in greengram and blackgram in the rabi season of 1994–95. It was applied at the rate of 0.5 and 1.0 kg active ingredient per hectare one month after sowing and at pod initiation stage. The safe waiting period of 12 to 15 days in greengram and 11 to 15 days in blackgram respectively, is reported.

2. Pal A.K., M.R. Pattnaik and H.K. Senapati, 1997. *Movement, distribution and leaching of carbofuran in soil columns*. Pesticide Research Journal. Vol. 9: No. 2; 165.

Abstract: Leaching losses, movement and distribution of carbofuran indicated leaching was more in coarse–textured laterite soil as compared to fine–textured alluvial and black soil and followed in the order: laterite soil is greater than alluvial soil and this is greater than black soil. Maximum amount of carbofuran was retained in the upper (0–10cm) layer of soil columns particularly in black alluvial soils. In laterite soils, the movement occurred upto 15 centimeters.

CUTTACK

CENTRAL RICE RESEARCH INSTITUTE (CRRI)

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The Pesticide Laboratory of the Central Rice Research Institute (CRRI) conducts studies on pesticide – microflora interactions in tropical rice soils, stability, microbial fate and transport of several commonly used insecticides (organochlorines, organophosphorous, and carbamates) in rice soils have been chronicled. In addition, research is carried out to investigate microbes in tropical soils which have the ability to degrade pesticides.

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Objectives:

- Studies on pesticide – microflora interactions in tropical rice soils.
- Studies on the microbial fate, transport and stability of several commonly used organochlorines, organophosphorous and carbamate pesticides.
- Isolation of microbes present in the soil with pesticide–degrading ability.
- Molecular biology studies on cloning and expression on dechlorinase activity.

Achievements:

- A microbe, *Sphingomonas paucimobilis,* has been isolated for the first time and has the ability to aerobically degrade all isomers of HCH, including recalcitrant beta and delta – HCH isomer.
- Work on transcription – mediated expression on several proteins upon exposure to HCH.
- Cloning of *Sphingomonas paucimobilis* indicated the presence of HCH – degradation gene sequence in both plasmid as well as genomic DNA of this bacterium.
- Particularly important from the standpoint of pollution of groundwater resources, is that HCH isomers, applied to flooded rice fields, can move down to a depth of 60 cm or more, contaminating shallow aquifers especially in delta areas.

Experts: *Dr. B. N. Singh, Director, Dr. N. Sethunathan (retired), Dr. K. Raghu Dr. T.K. Adhya, Dr. S.K. Apte, Dr. S.K. Sahu, Dr. A. Banerjee Dr. N.B.K. Murthy, Dr. V.R. Rao, Dr. R.C. Dani, Dr. D. Panda.*

Note: In addition to scientists, there are several others working in the area of pesticide research. It would be difficult to accommodate all the names.

Significant Research Publications

1. Adhya T.K., S.K. Apte, K. Raghu, N. Sethunathan and N.B.K. Murthy, 1996. *Novel polypeptides induced by the insecticide lindane (gamma–hexachlorocyclohexane) are required for its biodegradation by Sphingomonas paucimobilis strain.* Biochemistry and Biophysics Research Communication. Vol. 221; 751–761.

2. Adhya T.K., V.R. Rao, R.C. Dani, D. Panda and N. Sethunathan, 1995. *Leaching of hexachlorocyclohexane isomers in a flooded field unplanted or planted to rice.* Water, Air and Soil Pollution. Vol. 81; 1–9.

Note: *Most of the institutes visited, furnished relevant details on the pesticide research being conducted at their respective centres. However, there were a few institutes, which did not respond to letters requesting them to send information. Even after visiting them, constant telephonic reminders, letters through speed post and after visits by other colleagues from Toxics Link, we drew a blank. They are:

1. North Zone: RAU, Pusa, Bihar
2. South Zone: Department of Biotechnology, Anna University, Chennai, GKVK, Hebbal, Bangalore
3. East Zone: BKVK Agricultural University, Nadia, West bengal

4. West Zone: Jai Research Foundation, Vapi, Gujarat
5. Central Zone: MPVK, Jabalpur, Madhya Pradesh

** A few institutes have been mentioned in the address book but there is no mention about their contributions in the area of pesticide science in the directory, also there are a few institutes whose contributions are listed in the directory but have recently stopped doing research in pesticide science. The reasons these institutes have stopped or unable to do pesticides research are paucity of funds, new mandate, retirement/transfer of the experts and other institutional problems. These institutes are:

1. RRL, Jammu
2. KGH, Lucknow
3. Department of Studies in Applied Botany & Biotechnology, Mysore
4. Regional Occupational Health Centre, ICMR, Banagalore.

*** Laboratories researching exclusively on insecticide resistence have not been included in the directory.

Research Institutes with Facilities for Testing Pesticides

- Indian Institute of Chemical Technology, Hyderabad*
- Industrial Toxicology Research Centre, Lucknow*
- Indian Agriculture Research Institute, New Delhi*
- INTOX, Pune*
- Facility for Ecological & Analytical Testing
  302, Southern Laboratory
  Indian Institute of Technology
  Kanpur-208016
  Phone–0512 597844
- Indian Institute of Technology
  Hauz Khas, New Delhi–110 016
  Phone–011 6861977-85
- Sri Ram Institute of Industrial Research
  19, University Road, New Delhi–110 007
  Phone – 011 7257267, 7257860
  Fax – 011 7257676, 7256013
  Email – sridlhi@vsnl.com

*Complete addresses of the above mentioned institutes are given in the directory.

Note: Testing is conducted exclusively on payment basis.

List of Non–Governmental Organizations Working on Pesticides and Related Issues

Voluntary Health Association of India
40 Institutional Area, Behind Qutub Hotel,
New Delhi—110016
Phone— 011 668071/72
Email — vhai@unv.ernet.in
Contact — Dr J P Singh

Forum for Biotechnology and Food Security
96 A, Gautam Nagar
New Delhi —110 049
Phone — 011 6562326
Email — dsharma@ndf.vsnl.net.in
Contact — Devinder Sharma

Consumer Guidance Society of India
J Block, Azad Maidan
Mahapalika Marg
Opp. Cama Hospital
Mumbai — 400 001
Phone — 022 2621 612
Contact — N G Wagle

Consumer Education and Research Centre
'Suraksha Sankool', Thaltej
Ahmedabad–Gandhinagar Highway
Ahmedabad—380 054
Phone — 079-7489945–46/7450528/7451097
Email — cerc@wilnetonline.net
Contact — Mr Yellore

Note: CERC has a pesticide residue analysis laboratory.

Centre for Science and Environment
41 Tughlakbad Institutional Area
New Delhi –110 062
Phone — 011–6986399/6983394
Email — cse@cseindia.org

Note: CSE is setting up a pesticide residue analysis laboratory.

THANAL
Post Box 815
Kowdiar Post Office
Trivandrum 3
Kerala
Email — thanal@vsnl.net
Contact — Jayakumar

Research Foundation for Science, Technology and Ecology
A 60, Hauz Khas
New Delhi — 110 016
Phone — 685 3772, 651 5003
Fax — 685 6795
Email — vshiva@giasdl01.vsnl.net.in
Contact — Dr Vandana Shiva

Navdanya
Research Foundation for Science Technology and Ecology
A 60 Hauz Khas, New Delhi — 110 016
Phone — 685 3772, 651 5003
Fax — 685 6795
Email — rfste@ndf.vsnl.net.in
Contact — Dr Vandana Shiva

Tata Energy Research Institute
Darbari Seth Block, India Habitat Centre
Lodi Road
New Delhi — 110 003
Phone — 462 2246/460 1550
Fax — 4621770/ 4632609
Email — teri@teri.res.in

Note: TERI has a pesticide residue analysis laboratory.

Poison Centre, Department of Pharmacology
All India Institute of Medical Sciences
New Delhi — 110 029
Phone — 6864851, 6593282
Contact — Prof S K Gupta

Dr A T Dudani
C 35 Panchsheel Enclave
New Delhi — 110 017
Phone — 011 6864157

Glossary

Acceptable Daily Intake (ADI): The amount of pesticide which can be taken daily or in an entire lifetime, but still not show any toxic effects. It is expressed in mg/kg bodyweight.

Acute toxicity: A single exposure of a toxicant is lethal.

Chronic toxicity: Repeated exposures to small doses over a long–term period, causing poisoning.

Dissipation: The natural process of loss or removal of pesticide from the environment.

Farmgate: Crops available immediately after harvest.

LC_{50}: A statistical estimate of a dosage of the concentration of the toxicant which is responsible for 50 per cent mortality.

Maximum Residue Limit (MRL): The maximum concentration for pesticide residue on a crop or food commodity resulting from the use of pesticide.

The Insecticide Act, 1968: Enacted to regulate import, manufacture, sale, transport, distribution and use of insecticides with a specific objective to prevent risks to animals and human beings and for matters connected therewith.

The PFA Act, 1954: The Prevention of Food Adulteration Act has been enacted with the aim of ensuring purity in articles of food.

Synergism: The effect caused by a substance which is itself not a pesticide, but by its presence can increase the toxic effects of pesticides.

Waiting period: The minimum interval of time between last application of pesticide and harvest; if crops are harvested after the waiting periods, pesticides reach below their tolerance limit and so consumer safety is ensured.

Mutagenic: Capable of causing genetic defects.

Carcinogenic: Capable of causing cancer.

Cancer: Abnormal mass of tissue, the growth of which is uncoordinated when compared with parent tissue.

Teratogenic: Capable of causing foetal abnormality when adminstered to pregnant mother.

Immunosuppressive: Immunosuppressive chemicals are agents that initiate cellular or humoral (or both) immune responses (that is, they suppress the normal defence system of the body).

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JAWAHARLAL NEHRU UNIVERSITY

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Department of Zoology, University of Delhi

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About TOXICSLINK

TOXICSLINK is a non profit environmental organisation working towards freedom from toxic pollution. Operating since 1996, Toxics Link has three information outreach nodes in Delhi, Mumbai and Chennai respectively. The nodes provide information to grassroots groups and individuals and networks with others working on environmental toxicity issues.

Our mission statement:

'We are a group of people working together for environmental justice and freedom from toxics. We have taken it upon ourselves to collect and share both information about the sources and dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives for India and rest of the world.'

Other Toxics Link reports, published and forthcoming:

- *Not so inert after all!* Flyash: an environmental and health perspective. 1997
- *Landfills Deconstructed*: Technology, Management and Experiences. 1998
- *Status of Hazardous Wastes in India*: 1999
- *Cloning Bhopal*: Exposing the dangers in Delhi's environment. 1999
- *Common Effluent Treatment plants*: Technology, Management and Experiences (forthcoming)
- *Status of Persistent Organic Pollutants in India* (forthcoming)

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